50 Years of RDSO
Powering Indian Railways
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S.R. Agrawal

Research Designs & Standards Organisation
Lucknow
FOREWORD

We, in the Indian Railways, are living in exciting times. With the annual freight growth rate of 9%, the loading during 2006-07 is projected to be 726 million tonnes, a stupendous figure which looked unachievable a few years ago. The annual growth in passenger traffic is to the tune of 7%, and more than 17 million passengers are being transported everyday. Indian Railways are poised to create history by generating a cash surplus before dividend of Rs.20,000 crores and to achieve an operating ratio of 78.7%. With a booming economy, we will need to maintain the high rates of growth in the future.

Keen competition from the roadways and even the airlines is now a ground reality. Hence, growth of the Railways can be sustained by providing a reliable and safe travel at a lower cost. Since capacity expansion is capital intensive, this calls for substantial improvements in productivity and utilisation of assets, which has been, so far, largely achieved by innovation and cost effective technology inputs given by RDSO. Some of the examples are longer and faster trains, heavier axle load wagons with better pay to tare ratio, higher capacity coaches, double stack containers, crashworthy coaches, higher horse power Diesel & Electric locos with better fuel/energy efficiency, concrete sleeper and long welded rail tracks, LED signals, optical fibre communication etc. RDSO has significantly contributed to the recent turnaround of Indian Railways.

RDSO is completing 50 glorious years of service to the Indian Railways and the Nation. I am very happy that Dr. S.R. Agrawal, retired ADG/RDSO, has brought out this book “Fifty Years of RDSO : Powering Indian Railways” in the golden jubilee year of RDSO. Dr. Agrawal has served RDSO for 13 years in three different spells and has made significant contribution to the R&D effort on bridges and standardisation. With his long experience, he has comprehensively covered the R&D work done in RDSO during the past five decades, the present scenario and the activities planned for the future. The chapters on ‘The first Rajdhani’, Crashworthy design of coaches and Garib Rath make very interesting reading. I have great pleasure in commending this book written by Dr. S.R. Agrawal.

It is hoped that this book will enable not only Railway persons, but all others interested in Railways, to fully appreciate the role of RDSO in development of appropriate technology on Indian Railways and will serve as an inspiration to all those engaged in R&D.

(A.K. Rao)
Director General, RDSO

Lucknow dated 5-3-2007
RDSO is the sole organisation of Indian Railways providing inputs on all technical aspects including designs and standardisation. It is completing 50 years of its existence on 7th March 2007. During this period the IR has marched ahead carrying about ten fold increase in freight traffic and eight fold increase in passenger-kilometers. It broke the speed barrier of 60 miles/ hour (96 km/ h) in 1969 with the first Rajdhani Express between New Delhi and Howrah and is now running several fully air-conditioned Rajdhani, Shatabdi and Garib Rath trains at high speeds up to 150 km/ h. Passenger comforts have increased with better riding of coaches, improved interior designs and better lighting and other facilities. The safety on the Railways has also been increasing year by year. All technical inputs required for the growth and development of the Railways have been provided by RDSO.

Steve Jobs has stated

‘In most people’s vocabularies, design means veneer. It’s interior decorating. It’s the fabric of the curtains or the sofa. But to me nothing could be further from the meaning of design. Design is the fundamental soul of the human-made creation that ends up expressing itself in successive outer-layers of the product or service’.

Research, Designs and Standardisation are the key to growth and development particularly to a large organisation like Indian Railways. Even a little improvement due to improved design or R&D input in any component of fixed assets or rolling stock is multiplied thousands of times due to large number of similar components being used each year and the resulting benefits are enormous. Standardisation reduces the requirement of large inventories and also makes maintenance easier and economical.

I have always believed that any R&D input in IR gives hundreds of times more benefit than could be obtained by an individual in construction and maintenance or operation of trains. I have utilized 13 years of my service as an IRSE officer in RDSO mostly in Bridges and Structures Directorate in three spells, firstly as Assistant Director/ Dy. Director (B&S), from June 1966 to October 1974 then as Director Standards (B&S) from May 1987 to August 1990 and finally as Addl. Director General for about a year prior to superannuating in October 1996. During my first tenure at RDSO, I was awarded Ph.D. in Civil Engineering for my thesis entitled ‘Dispersion of Tractive and Braking Forces in Railway Bridges’, from University of Roorkee, Roorkee. When I look back, I have the happiest and fulfilling moments of seeing the results of the R&D work done at RDSO being used in IR and resulting in retention of hundreds of old bridges for higher loads. If it is true for me, it would be true for hundreds of others who have contributed to R&D.

Therefore, when Sri A. K. Rao, Director General, RDSO offered me to write a book on RDSO at the occasion of its Golden Jubilee, I readily agreed to it. However, it was a difficult task as even though I had a long association with RDSO, I had mostly been associated with Bridges and Structures Directorate. The writing of the book required a full knowledge of RDSO and its contributions over the past fifty years.
I interacted with a number of serving and retired persons of RDSO to have their views and suggestions which have been very valuable. My interactions with Sri A.K. Rao in connection with the book have been extremely useful and have enhanced the contents of the book. I went through a number of books and the Annual Reports of RDSO, Year Books of IR, and different publications of RDSO and IR about the various contributions and spent considerable time in the Central Library of RDSO. A letter was sent to all the Directorates of RDSO to give details of contributions during past five decades along with the R&D facilities and any other significant aspect which they may feel useful for the book. All the officers of RDSO fully cooperated and have given details and these have been used in writing the book. There are twenty two directorates, each one is continuously engaged in R&D, designs and standardisation work and also has been assisting IR in adoption and absorption of latest appropriate technology, bringing about hundreds of improvements each year.

In the book, an attempt has been made to present fifty Years of RDSO so that one can understand and appreciate the role played by the RDSO for powering Indian Railways for growth and development. The reader may appreciate how R&D helped to break 100 year old speed barrier of 60 miles/hour (96 km/h) by introducing first Rajdhani Express in March 1969 at a speed of 120 km/h breaking the 100 year old speed barrier of 60 miles/hour (96 km/h) without any additional inputs except for the cost of the rake. Chapter – 5 ‘Powering the Growth of IR’ gives how RDSO has been providing technical inputs minimal expenditure by improvements in track, bridges, signalling and telecommunications, traction installations along with improvements in rolling stocks viz locomotives, coaches and wagons.

The book has been essentially divided into two sections - Section I ‘Fifty Years of RDSO : Powering Indian Railways’ and Section II ‘Contribution by different Directorates’ along with ‘Panorama’ containing the bird’s view of different activities at RDSO.

Section I is divided into nine chapters and gives the history of RDSO, its contributions in early years, the main achievements, the present scenario and the journey ahead.

Chapter – 1 ‘Origins’ explains how and when RDSO was created. Chapter – 2 ‘The Early Years’ brings out the scenario of growth and development of RDSO in the first two decades and how it contributed to IR in developing materials and equipment and components for import substitution and helped IR for carrying increasing freight and passengers with very little financial inputs by adoption of appropriate technology. Chapter – 3 ‘Institutional Mechanism’ deals with the institutional mechanism for identification of R&D projects to be taken-up by RDSO and to steer them on the correct path for benefit of IR.

Chapter – 4 ‘Breaking the speed barrier: The First Rajdhani’ gives a fascinating story as to how fully air-conditioned first Rajdhani train between New Delhi and Howrah was introduced on 1st March 1969 at a speed of 120 km/h breaking the 100 year old speed barrier of 60 miles/hour (96 km/h) without any additional inputs except for the cost of the rake. Chapter – 5 ‘Powering the Growth of IR’ gives how RDSO has been providing technical inputs...
in the infrastructure viz track, bridges, signalling, telecommunications and in the improved designs of rolling stocks including locos (electric and diesel), coaches and wagons for enabling IR to carry increasing freight and passengers safely economically and speedily.

Chapter – 6 ‘Crashworthy design of coaches’ describes how RDSO in the recent past has improved the earlier ICF coaches to make them crashworthy by detailed design and prototype testing. These coaches will ensure minimum damage to coaches in the passenger occupied area in case of collisions. Chapter – 7 ‘Garib Rath’ describes how fully air-conditioned train with all modern facilities and riding comfort equal to Rajdhani and Shatabdi trains have been introduced recently on IR to cater for the passengers who cannot pay the fares of Rajdhani and Shatabdi trains. The fares are considerably less than AC 3-tier for sleeping coaches and less than AC Chair Cars for seating accommodation.

Chapter – 8 ‘RDSO Today’ describes the present scenario of RDSO along with its organisation, support system, quality policy, infrastructure, testing laboratories, mobile test facilities, collaboration with research and academic institutions and international cooperation. It also briefly gives the recent achievements of RDSO. Chapter – 9 ‘The Journey Ahead’ gives the future scenario and the challenges ahead along with the R&D areas to be tackled by RDSO regarding freight transport, safety, reliability of assets, upgradation and modernization, increased throughput and speeds, environment, passenger comfort and cost optimization and energy efficiency along with the action already planned by RDSO.

Section II ‘Contribution by different directorates’ gives the brief of the directorates, their R&D facilities and their contribution to research, designs and standardisation during different periods. This provides information as to how RDSO has been taking up a large number of projects and has been bringing about improvements progressively in IR apart from quantum jump in technology inputs.

Bridges & Structures Directorate explains R&D efforts done for retention of 100 year old railway bridges which have out lived their codal life and have been retained for heavier loads and high speeds without rebuilding them in general and with retrofitting at little cost in several other cases. Track Design and Track Machines & Monitoring Directorates indicate how track has been modernized with PSC sleepers, elastic fastenings, and large scale provision of LWR/CWR along with mechanized maintenance and inspections with track recording cars and ultrasonic flaw detection of rails. Geotechnical Directorate has been providing advice on all formation and other geotechnical problems. Traction and Installation Directorate has been continuously bringing out improvements in OHE installations for improved reliability, economy and safety. A large number of improvements have been introduced by Signal and Telecom Directorates for improved safety and increased linecapacity.

Motive Power and Electric Loco Directorates have helped in introduction of latest technology on IR and its large scale absorption and manufacture of the locos in India indigenously at much cheaper costs. These Directorates have developed a large number of new designs of higher horse power with improved braking and reliability. Engine Development Directorate has brought out interesting modifications to ALCO locos which have resulted in specific fuel consumption reduction of about 10% along with several other advantages.
Power Supply and EMU Directorate has provided a number of new designs and improvements leading to substantial economy and improved quality of service with better reliability. Carriage Directorates has contributed for more passenger comfort increased seating capacity of coaches with improved interiors and better riding with improved safety. Wagon Directorate has designed a number of various types of wagons with latest state of art technology for carrying more freight with higher pay load to tare weight ratio, higher axle load and reduction in length so that more goods can be loaded in shorter trains. Wagons have also been designed for higher speeds of 100 km/h. Psycho-technical and Traffic Directorates have been contributing to safety and improved operations etc. M&C Directorate has contributed significantly by developing suitable materials for critical safety components. It has been investigating the cases of fatigue failures and suggests remedial measures to avoid recurrence. It has been carrying out fatigue failure investigations and propagated ultrasonic testing of rails, axles and wheels etc. Other Directorates have also been contributing significantly.

Section II contains separate chapters for Bridges & Structures, Track Design, Track Machines and Monitoring, Geotechnical Engineering, Signal, Telecom, Motive Power, Engine Development, Carriage, Wagon, Testing, Traction Installation, Electric Loco, Power Supply & EMU, Metallurgy & Chemical, Quality Assurance, Psycho-technical, Research, Traffic, Architecture, Bridges & Floods Directorates and Computer Wing. One will be able to appreciate the contributions being made by different directorates individually and collectively for powering Indian Railways by going through them.

‘Panorama’ includes typical pictures of distinguished visitors along with some pictures of meetings like Central Board of Railway Research, Governing Council of RDSO and meetings with foreign delegates. There is a brief write-up about Rajbhasha Cell of the RDSO along with its contribution. RDSO’s Women Welfare Organisation (RWWO) plays an important role in social welfare of the employees and their families and a bird’s view of the same is included. Recreation, Games, Sports, Medical and Educational facilities are important for good health and cheerful environment in the campus. RDSO has been looking after these aspects very well and a small write-up gives the facilities for games, sports, recreation, medical care and education. Names of the players who have represented IR or the State in national games have also been given. A list of recipients for R&D contribution awarded at Railway Minister’s level since 1989 has been given with the gist of their contribution.

My purpose of writing the book would be served if even a few people get inspired to take up R&D and / or promote the cause of R&D.

Lucknow dated 5-3-2007

(S. R. Agrawal)
In most people's vocabularies, design means veneer. It's interior decorating. It's the fabric of the curtains or the sofa. But to me nothing could be further from the meaning of design. Design is the fundamental soul of the human-made creation that ends up expressing itself in successive outer-layers of the product or service.

— Steve Jobs —
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Origins

Indian Railways developed and grew as small independent units under different administrative setups since 16th April, 1853 during nineteenth and early twentieth century. The railways were owned by a large number of Companies and States in the pre-independence era, without any coordination amongst each other in respect of rolling stock and other railway infrastructure. With growth in traffic, the need for interchange of rolling stock amongst various railways increased, highlighting the necessity of coordination, standardisation of permanent way and rolling stock. The first step in this direction was taken with the introduction of Indian Railway Conference Association (IRCA) in 1903. This brought about some coordination but was not adequate.

In January, 1930, Central Standards Office for railways (CSO) was set up by the Railway Board to standardize designs and specifications for track, bridges, signalling and rolling stock etc. with head office at Simla. The activities of this office towards the introduction of standard designs for the railways on all India basis proved successful. The CSO was made permanent in 1935 along with addition of staff to carry out extensive technical research to enable IR to keep abreast with modern development in Railway practice.

In railway construction, maintenance and operation the outlay on track, locomotives and rolling stock absorbs the greater portion of finances. The greater the variety of equipment, the higher is the cost of production of different types and the lower the degree of interchangeability of parts. The quest for economy drew attention to the need for standardisation of equipment and better utilization of local raw materials. In 1935, research on IR began when two officers were assigned the task of determining the maximum loads which existing engines could haul, and the maximum speeds they could attain under various service conditions. This was done by one hydraulic Dynamometer Car acquired by GIP Railway in 1931, one of the few test cars then available on any railway in the world. Next followed investigations into rail-wheel interaction. The research was organised as part of CSO.

After independence of the country, the railways came under state control and were grouped in Railway Zones. There were nine zones for about four decades and since 1st April, 2003, there are sixteen Zones viz. Central, Eastern, East Central, East Coast, Northern, North Central, North Eastern, Northeast Frontier, North Western, Southern, South Central, South Eastern, South East Central, South Western, Western and West Central Zones.

All the railways having come under unified state control, the benefits of even small improvements in designs and specification were more pronounced. Prior to independence most of the designs of locomotives, coaches and wagons as well as of important bridges, rail and rail fittings and fastenings etc were provided by British firms such as M/s Rendel, Palmer and Tritton without any transfer of technology.

Railway Testing and Research Centre (RTRC)

With independence came a shift in emphasis. The urge towards national self sufficiency together with enlargement of activities of Indian Railways in the field of
design and manufacture, brought in the wake the demand of more indigenous applied research in railway technology. The Research section of CSO was reorganized and established on 1st September, 1952 as a separate directorate of the Railway Board with headquarters at Lucknow as Railway Testing and Research Centre (RTRC) with two sub-centers at Lonavla and Chittaranjan.

The Railway Testing and Research Centre (RTRC), Lucknow was formally inaugurated on 12th February, 1954 by Honorable Chief Minister of Uttar Pradesh, Sri Gobind Ballabh Pant in presence of Sri F. C. Badhwar, the then Chairman, Railway Board. Sri S. L Kumar was the first Director Research. It had the following research staff:-

**Lucknow Centre**

Sri M. N. Bery, Dy. Director (Publication)

Sri R. Basu Choudhury, Dy. Director (Civil)

Sri M. V. Kamlani, Dy. Director (Mechanical)

Sri M. S. Murti, Dy. Director (Electrical)

Sri M. N. Bery, Dy. Director (Publication)

Sri R. Basu Choudhury, Dy. Director (Civil)

Sri M. V. Kamlani, Dy. Director (Mechanical)

Sri M. S. Murti, Dy. Director (Electrical)

(*Booklet entitled ‘Railway Testing and Research Centre, Lucknow’ published on the occasion of formal inauguration – 12th February 1954)

**Field Officers**

Sri B. V. Mallya, Sri C. S. P. Sastry and Sri Ramchandani and 15 research assistants.

**Lonavla Sub-Centre**

Sri A. V. D’Costa, Joint Director Research (Civil)

Sri U. G. K. Rao, Dy. Director (Soil Mechanics) and three research assistants.

**Chittaranjan Sub-Centre:**

Sri R. G. Bhatwadekar, Joint Director (M&C)

**Assistant Officers**

Sri S. Ramnujam and Sri M. N. Bhide and three research assistants.

The Lucknow Centre carried out research on fuel, dynamic effect of vehicles on track and bridges, and riding qualities and performance tests on locomotives and rolling stock assemblies and components. The Documentation and Information Service published bulletins and summaries of important researches conducted in India and abroad.

The Lonavla Sub-centre dealt with research in connection with buildings, foundations and concrete engineering as applicable to IR. The Chittaranjan Sub-centre in close coordination with Chittaranjan Locomotive Works (CLW) conducted chemical and metallurgical studies on paints, water softeners, lubricants, bronzes, metals and metal processing.

**Administrative Building**

RTRC had a three storied Administrative Building (Photo on p 7) with 30,600 square feet of covered area at a cost of Rs. 7.5 lacs constructed in 15 months. Sri N. B. Shroff was the architect of CSO and Sri B. C. Ganguli was the Divisional Engineer. On the ground floor were housed the field units, model room, testing laboratories and workshops. The second floor comprised of main administrative offices, meeting hall, library, documentation, reproduction and photographic laboratories. There was a rest house on third floor. This building is still the main administrative building of RDSO where Director General and all administrative staff have their offices. This
building has been renamed as ‘Anusandhan Bhawan’ in 1995 but is still mainly known as Administrative Building.

**Research Yard**

The research yard was laid at a cost of Rs. 6.5 lacs served both by BG and MG track taking of the Lucknow–Kanpur main line of Northern and North Eastern Railways. The layout provides stabling accommodation for field test cars and their supporting staff cars along with shed accommodation for conducting impact tests on carriages and wagons. A squeeze test frame with dual gauge entry is located in the yard for static testing for prototype carriage and wagons under-frames and integral shells.

**Laboratories, Instrumentation Cars and Mobile Laboratories**

At the time of inauguration of RTRC, there were five field test units viz one BG Hydraulic Dynamometer Car, three Oscillograph cars interchangeable between BG and MG and one BG fuel Test Car. There was also a Track Recording Car with Central Railway working under directions of the Research Directorate on IR. There were several test laboratories.

Evolution of Research Designs and Standards Organisation (RDSO): The importance of R&D was realized by the Railway Board and it was felt that for better coordination and results, all the activities connected with research, designs and standardisation should be in one organisation located centrally and the Railway Board merged Central Standards Office and Railway Testing and Research Centre along with sub-centers at CLW, Chittaranjan and Lonavla into one unit.

Railway Board vide their letter No. E53RB7/ 10/ 2(RBI) dated 7th March, 1957 (copy placed as Annexure-I), ordered that all the work connected with Research, Designs and Standardisation of IR be placed under one organisation to be called as Research, Designs and Standards Organisation (RDSO in brief) by merging RTRC and CSO, headed by an officer of the rank and pay of a General Manager and designated as Director General (DG). In addition to the staff and officers of CSO and RTRC, the following additional posts were sanctioned:-

Thus Director General had three Directors in charge respectively of:-

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<th>S. N.</th>
<th>Designation</th>
<th>Number of posts</th>
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<tr>
<td>1</td>
<td>Director General</td>
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<td>2</td>
<td>Directors Standardisation Civil and Mechanical Engineering.</td>
<td>3</td>
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<tr>
<td>3</td>
<td>Joint Directors Track, Mechanical Research, Electrical Engineering</td>
<td>3</td>
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<tr>
<td>4</td>
<td>Dy. Director (S&amp;T) by upgrading a post of Assistant Chief Design Engineer of CSO.</td>
<td>1</td>
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<td>5</td>
<td>Secretary to DG of Dy. Director Status.</td>
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- **Director Civil Engineering (Standardisation):** All works being done in the Civil Engineering and Architecture Sections of CSO;
- **Director Mechanical Engineering (Standardisation):** All works of Locomotive, Carriage and Wagon and Electrical Sections of CSO;
- **Director Research:** All works of RTRC.

**Functions**

RDSO is the sole organisation of IR for
all R&D work and functions as technical advisor to Railway Board, Zonal Railways and Production units. Basically the major functions are:-

- Development of new and improved designs;
- Development, adoption, absorption of new technology for IR;
- Development of standards for materials and products specially needed for IR;
- Technical investigations, statutory clearances, testing and providing consultancy services;
- Inspection of critical and safety items of rolling stock, locomotives, signalling and telecommunication equipment and track components.

The RDSO came into existence as an attached office of the Ministry of Railways from 7th March, 1957 which is clear from the ‘Reports of the Railway Board on Indian Railways for 1956-57’. The report in chapter VI (RESEARCH, DESIGN AND STANDARDISATION, p-77) states as under:-

“Para 99. General – With effect from 7th March 1957, the Central Standard Office for Railways and the Railway Testing and Research Centre were merged into a unified organisation called Research, Design and Standardisation Organisation”.

The headquarters functioning of RDSO continued from Simla till early sixties. Sri P.C. Neogi, IRSE, was the first Director General of RDSO from 27th April 1959 to 6th November 1960 and continued to work from Simla. Publications including annual reports of RDSO have been issued from Simla till early sixties. A list of officers working in RDSO during 1959-60 in various directorates and wings of RDSO is given as Annexure- IV.

Thus, RDSO came into existence on 7th March 1957, completing 50 Golden Years now.
The Early Years

Introduction

The early years of RDSO have been a year of hardships and achievements. Though, RDSO was created in 1957, there were very little infrastructure facilities and there was acute shortage of residential accommodation. The campus is located in a place which was sparsely populated. There were frequent thefts and dacoities in RDSO campus. Even when residential accommodation was developed in the colony, residents had to engage watchmen for safety during night. There were no suitable educational facilities for children in the campus. A large scale shifting of officers and staff from earlier CSO, Simla was to be done early. However, the moral of officers and staff was high. They were full of zeal and enthusiasm to do something for IR. They were working hard and were also enjoying life. The officers club though not well developed at that time was buzzing with activities. The stadium used to be full with players and a number of tournaments used to be held regularly.

There was thrust due to growth and industrialization of the country calling upon the IR to carry substantially increasing freight and passengers. This called for immediate necessity of results based on R&D to be put to use on the Railways. It rose to the occasion due to commitment, dedication and hard work of officers and staff. It was in these formidable years that first Rajdhani was introduced on 1st March 1969 between New Delhi and Howrah at a speed of 120 km/ h breaking a hundred year old speed barrier of 60 miles/ hour (96 km/ h) without any additional expenditure. A lot of innovations were done and appropriate technology suiting the Indian conditions was adopted.

Infrastructure and growth of RDSO

Research Designs & Standards Organization as an attached office of Ministry of Railways was created by merging Central Standards Office for Railways (CSO), Simla, and Railway Testing and Research Centre (RTRC), Lucknow, in March 1957. Some additional posts of officers were also sanctioned for RDSO by the Railway Board. Though RDSO was created in 1957, it continued to function from CSO, Simla, till early sixties. The senior most Director of CSO was looking after the work of RDSO till the first Director General was posted in 1959. The RDSO had apart from CSO, Simla and RTRC two sub-centers one at CLW, Chittaranjan for M&C and a wing for diesel-electric and steam loco designs and the other at Lonavla for Civil Research particularly building materials, concrete designs and soil investigations. The Lonavla sub-center was shifted to RDSO, Lucknow towards the end of fifties as a part of B&S Research Wing.

The post of Director General RDSO continued to be operated from Simla for a few years. Sri P.C. Neogi was the first Director General of RDSO from 27.4.59 to 06.11.60. Sri Qurban Singh was the Director General from 8.11.60 to 24.02.61 and Sri RE DeSa was the Director General from 22.10.61 to 31.03.64. Sri RE DeSa had his secretariat at Lucknow and have moved to Lucknow sometime in 1962-63. A list of Director Generals of RDSO along with their photographs is placed at p 210.
The RDSO consisted of four directorates in 1960-61 as under (RDSO Annual Report 1960-61, p-1) out of which only Research Directorate was located at Lucknow:-

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<th>Directorate</th>
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<tr>
<td>Civil Engineering Designs &amp; Standards Directorate</td>
<td>Track; Bridges &amp; Structures; Signalling &amp; Telecommunications; and Architecture.</td>
</tr>
<tr>
<td>Mechanical Engineering Designs &amp; Standards Directorate</td>
<td>Steam Locomotive; Diesel; Electric; Carriage; and Wagon.</td>
</tr>
<tr>
<td>Research Directorate</td>
<td>Civil Research; Mechanical Research; and Metallurgical &amp; Chemical Research.</td>
</tr>
<tr>
<td>Bridges &amp; Floods Directorate</td>
<td>* Came into existence in 1960</td>
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(*The Bridges & Flood Directorate is located at Delhi for hydro-metrological studies on IR in implementations of the recommendations of the committee set-up by the Government under the Chairmanship of Dr. A.N. Khosla whose report was published in October 1959. The Directorate is to collect, systematize and analyze all the data received from the Railways and other organization and establish values of co-efficient in an empirical formula to be evolved for the maximum flood discharge, which will enable the Railways to adopt measures to avoid wasteful expenditure in constructing unnecessarily long bridges and at the same time eliminating the possibility of washaways of bridges during high floods, resulting from in-adequate provision of waterways or protective works.)

In 1957, at the time of commissioning of RDSO, only RTRC building which was called as Administrative Building of RDSO and houses the Director General and his secretariat, Additional Director General, Executive Director (Research), Executive Director (Track), Executive Director (Finance) along with a few other sections was existing. This building was renamed as Anusandhan Bhawan in 1995 but is still continued to be largely known as Administrative Building. This accommodation at Lucknow was not even sufficient for the staff and officers of RTRC. Therefore, before shifting the staff and officers additional office accommodation along with residential accommodation was essential.

During 1957-58, only 26 residences for officers and 133 staff residences i.e. a total of 159 residences located on the east side of Lucknow–Kanpur line in RDSO Campus were available. The officers and staff strength at RTRC at Lucknow was over 300. The total officers and staff strength as on March 1961 (RDSO, Annual Report 1960-61, p-1) was 73 officers and 946 staff i.e. total of 1019. Only about 40% were stationed at Lucknow and rest were mostly at Simla. Most of staff and officers in RDSO at Lucknow were residing in private leased accommodation till almost the end of sixties due to acute shortage of accommodation in the RDSO campus. The officers and staff strength had been increasing year by year due to increased activities at RDSO necessitated for R&D activities, indigenization and improvement of designs
Administrative Building of RDSO (Anusandhan Bhawan)

The officers and staff strength in 1962 was 1226 which increased to 1656 in 1965 and then further increased to 3081 in 1971. The officers and staff strength during various years are given in Annexure-VI.

Due to acute shortage of office and service buildings accommodation, it was not possible to shift design, standardisation offices from Simla till some accommodation could be provided. Therefore, construction of service buildings and residential accommodation was taken up in a phased manner. At first, temporary sheds were constructed on the west side of Lucknow–Kanpur line for accommodating Labs along with the staff and offices during early sixties.

Typical old sheds still existing in RDSO for office and lab accommodation constructed in early sixties as shown in photo below.

Construction of three storied Annexe-I in 1965 with floor area of 10621 m² was taken-up and completed in 1968. This considerably eased the problem of office accommodation and Lab buildings. This was renamed as Manak Bhavan but is still popularly called as Annexe-I. This building now accommodates Carriage, Wagon, Computer, Electrical, Power Supply & EMU, Motive Power, Telecommunications and Signal Directorates along with a few laboratories. With further growth of RDSO, there was shortage of office accommodation. Therefore, six storey high Annexe-II with floor area of 7079 m² was completed in 1986. This was renamed as Abhikalp Bhavan but is still commonly known as Annexe-II. This
essentially accommodates Metallurgical & Chemical, Traction Installation, Bridges & Structures, Psycho-Technical, Quality Assurance and Traffic Directorates along with library on the fifth floor. Separate permanent buildings for Brake Testing Lab, Fatigue Testing Lab, Track Research Lab, M&C Research Lab, Signal Lab, B&S Labs etc. were constructed. Large scale construction of housing was done in the RDSO campus during sixties and seventies to accommodate most of the officers and staff within the campus so that they could give their services to RDSO with full devotion and commitment. Presently, there are 194 residences for officers and 1825 residences for staff in the campus. Now there is no shortage of accommodation in RDSO.

Electrical and Diesel Design Wing under the charge of an Additional Director were shifted from Simla to Lucknow during the year 1962-63 (RDSO Annual Report 1962-63, p-1). The list of senior officers up to Dy. Directors level at RDSO in December 1964 is placed as Annexure-V (Classified list of Indian Railways, December 1964). This indicates that the Mechanical Design Directorate with all its wings, B&F Directorate and part of the Civil Design Directorate had shifted to Lucknow. Civil Design Directorate along with all its wings fully shifted to RDSO by 1966. Thus consolidation of RDSO was completed by 1966 except Metallurgy & Chemical Directorate (M&C) under Jt. Director was working at CLW, Chittaranjan which was shifted to RDSO, Lucknow gradually between 1967 to 1972.

With the increase in traffic demand on IR, RDSO was called upon to increase its R&D activities including design and standardisation functions. A number of new directorates were created so that more specialized services could be rendered. At present there are 21 directorates for technical work along with separate directorates and wings for providing support to the R&D team.

**Expenditure on R&D**

The annual expenditure on R&D as given in the Annual Report of RDSO for 1960-61 was Rs. 56.11 lacs. The expenditure increased to Rs. 63.7 lacs during 1961-62 and Rs. 77.24 lacs during 1962-63. The expenditure has been rising and was Rs. 74.45 crores in the year 2005-06. The expenditure on R&D has been increasing year by year along with increase in the revenue earnings of IR. The revenue earnings in 2005-06 were Rs. 59,491 crores. It will be interesting to note that the ratio of expenditure on R&D to the revenue earnings of IR has remained throughout between 0.15% to 0.2%. The achievements of RDSO to the service of the nation and IR in particular are remarkable with such low expenditure on R&D including standardisation.

**Library**

RDSO has Central Library along with separate libraries with the directorates. The Central Technical Library of RDSO is valuable source of information and knowledge for every inquisitive person. The Central Library was initially located on the first floor of the RDSO’s Administrative Building. The library was shifted to Manak Bhawan (Annexe-I) sometime in 1969 and was again shifted to 5th floor in Abhikalp Bhawan (Annexe-II) during 1988 where it is presently located. The library has more than 1.70 lacs volumes comprising of books, reports, specifications, translation of science, engineering technology, management and Railways etc. About 160 technical journals and magazines both Indian and foreign are regularly subscribed by the library.
**R&D Activities**

Sixties and seventies were the formative years for the growth and development of the country when very little foreign exchange was available for import of technology. Due to industrialization and development of the country, IR was required to carry more and more traffic each year. The net-tonne-kilometers (NTKM) which is an important index for freight traffic, increased from 37,365 NTKM in 1950-51 to 110,696 NTKM i.e. by 2.95 times (IR year Book 2004-05). The track and bridges along with the rolling stock were of old designs suitable for light loads. The financial conditions were such that increasing traffic had to be carried with minimum inputs by adoption of appropriate technological innovations along with such changes which could be done without much expenditure. The Research Wing carried out extensive instrumented field and laboratory tests and trials on equipment and materials for Railway use. The field failure cases were investigated to know the reasons and avoid recurrence. An intensive search for materials and processes whereby indigenous manufacture could replace expensive foreign imports was done. For field investigations an Instrumentation Lab was set-up along with a large number of oscillograph recording equipments. Different types of transducers such as accelerometers, pressure cells and LVDTs were developed and used for field investigations. Some of the important contributions of the first two decades of RDSO were as under:-

**Bridges**

After independence and with the development of the country and industrialization, traffic was growing and need was felt to increase the speeds of the trains along with increasing trailing loads with operation of coupled diesel electric locos. Railway Board ordered RDSO in 1960 to take-up investigations for introduction of high speeds. Necessity was also felt to increase the axle loads by revising the loading standards. It was an extremely difficult challenge as 70% of over 1,21,000 bridges on IR are more than 100 years old and have outlived their codal life. They were designed and constructed in nineteenth century or early twentieth century when there was no provision for longitudinal forces in the design codes and the axle loads were light. There were hundred of bridges in distressed condition. Rebuilding of bridges is very costly and time consuming and requires lot of traffic blocks which affect the train running. Therefore, the first task of B&S Directorate was to study different types of bridges theoretically and also find out reserve strength by Lab and field trails along with study of the world literature. This has been done during sixties to eighties.

- Assessment of strength of old masonry arch bridges: There are about 21,000 masonry arch bridges and culverts on IR most of them more than 100 year old. Static, dynamic and destruction load tests were done by RDSO during sixties over more than a dozen bridges to find out the reserve strength and strength contribution by its various components. Based on these tests, a test criterion was evolved based on BRS criterion of UK suitable for IR conditions and has been incorporated in IRS Arch Bridge Code. The test criterion and ‘Survey and Tabulation Method’ developed by the author have enabled to retain hundreds of old masonry arch bridges particularly on MG to BG conversion projects and have resulted in savings of more than hundred crores of rupees.
- Investigations for Dynamic Effects on Girder Bridges: IRS Bridges Rules provided for an impact factor for speeds up to 100
km/h which was based on trials done with steam traction. With introduction of diesel electric locos and their running at higher speeds, it became necessary to conduct trials on different types of bridges at various speeds. The trials were commenced in early 1968 first on Bridge No. 66 of 18.3 m span girders on Varanasi-Zafrabad section of NR. The girders were strain gauged to record bending moments and shear forces at different locations. LVDTs were used for recording deflections. The measurements were recorded under both WP steam loco and single and coupled WDM4 diesel electric locos at various speeds up to 136 km/h. The tests for dynamic effects have also been done on number of other bridges of different spans under various speeds on both BG and MG. Based on the test results provision of dynamic augment has been revised in IRS Bridge Rules. The revised dynamic augments have provided relief in the design loads particularly for longer span bridges and have therefore made it possible to reduce the cost of construction along with permitting higher speeds. Some tests have also been done on ballasted deck bridges.

- Study of dispersion of tractive and braking forces on bridges into various bridge components including bridge approaches: This has been a major problem as due to increase in trailing loads with higher horse power locos with improved air brakes etc., the longitudinal forces have been increasing as indicated earlier. Exhaustive trials were done on Sone Bridge of 14×76.3 m with two shore spans of 30.5 m in 1967. The strains and forces were recorded in various bridge components namely bottom booms, bearings, bridge piers, rails both main rails and guard rails and in Centre Buffer Coupler (CBC). The test train consisted of three WDM4 locos followed by 30 box wagons loaded to a gross weight of 60 t each. The force distribution was recorded under running trains as well as under test train with various conditions such as (i) Sudden application of brakes; and (ii) The maximum tractive effort exerted by the locos placed in the desired position on the test span with box wagons away from the test spans fully braked. These trials enabled to understand more rationally the distribution and dispersion of tractive and braking forces in Railway bridges.

For plate girder bridges a special type of bearing stool of double ‘I’ section was developed, first of its kind in the world, and was instrumented and calibrated in the B&S Lab and used for further trials on 6×18.3 m Varuna Bridge on Varanasi-Zafrabad section. The trials have been conducted under various conditions on number of bridges and have led to very good understanding of dispersion of tractive and braking forces in Railway bridges. A theoretical analysis has been done and LFDISP programme has been developed for computing of dispersion of tractive and braking forces. The analysis and the trials have led to several revisions in the codal provisions for dispersion of tractive and braking forces in IRS Bridge Rules. The study also revealed the method for retaining existing sub-structures by replacing existing bearings with suitably designed elastomeric bearings. These have led to retention of hundreds of bridge sub-structures on IR particularly during gauge conversion projects leading to savings of over hundred crores of rupees.

- Apart from standard designs for bridges, special designs for important bridges including ROBs and buildings were issued by the RDSO. Field problems including determination of secondary stresses in Brahmaputra bridge girders near Guwahati were also studied.

The above works enabled to retain existing bridges for higher axle loads and speeds with no inputs or very little input by strengthening/retrofitting.
Track

Railway Track on IR consisted of light rails with maximum of 90 lbs/ yard with UTS of 72 N/mm² with rigid fastenings such as dog spikes, round spikes etc. The rails were 12-13 meters long with fish plated joints. These were not suitable for heavier loads, high density of traffic and higher speeds. The traffic was increasing and financial resources of the country were limited and import of materials was not feasible. The thrust of R&D was to optimize the use of existing track with as little inputs as possible. Therefore, to start with the research was essentially concentrated on understanding the track better. Measurement of stresses in the rails due to traffic, thermal changes and speeds were done and the design was modified. A 52 kg/m rail was designed by the RDSO and was used on BG. Extensive laboratory tests and field trials were done by Track Research Wing. Track characteristics including that of its fittings and fastenings were recorded and analysed by strain gauging the rails and with the help of transducers fitted in the track under running train loads at various speeds. These studies enabled to understand the track better. The fishplates were the weakest link and were resulting in fractures. Therefore, longer fishplates of 24 inches were used on BG with improved fish bolts. Cropping of the hogged rails was done to reduce impact on joints. In metal sleeper track, the joint sleepers were supported on slightly over-packed joint sleepers along with shoulder sleepers. Rigid fastenings work loose with traffic and speeds, therefore, a number of elastic fastenings similar to Pandrol clip were tested and introduced on IR. Measured Shovel Packing (MSP) was used with Directed Track Maintenance (DTM) in a big way in sixties and early seventies. The investigations revealed that with better maintenance the track stresses are reduced and deterioration of the track geometry is slower. This reduces the requirements of the maintenance efforts leading to the savings in cost of track maintenance along with better riding comfort. Therefore, monitoring of the track with track recording cars was introduced on important routes. Track tolerances for various types of defects were fixed. The maintenance practices were changed and mechanized maintenance of track was introduced. This enabled to introduce Rajdhani Express on existing track with no inputs in track except for improving its geometry by mechanized monitoring within specified track tolerances with improvement in maintenance practices particularly MSP and DTM.

Simultaneously, design of concrete sleepers were finalised, design of elastic fastening system were developed, design of turnouts were improved and large scale adoption of Long Welded Rails/ Continuous Welded Rails (LWR/ CWR) was done. This has led to modern track suitable for higher axle loads and high speed operation of trains.

Geotechnical Engineering

The Geotechnical Engineering Directorate has essentially dealt with problems connected with Railway embankment including blanketing material, specifications of ballast, side slopes and have been preparing detailed specifications and have been issuing guidelines to Zonal Railways on the various geotechnical aspects. It is also being rendering advice in case of slope failures, poor formation on soft soils, sinking of track and has been suggesting rehabilitation measures. It also gives advice to Zonal Railways with regard to various types of geotechnical problems including foundations etc. It carries out detailed soil investigations in Lab and in
field as required. These services have been very useful to IR for providing safe and economical formation.

**Signalling**

Design, modification and introduction of various types of signalling systems on IR keeping in view the latest developments was done after developing appropriate designs, prototypes and testing. Improvement of the existing equipments to save foreign exchange to make it safer and to reduce cost of maintenance was also done. Preparation of specifications for signalling equipments and their revisions and updating in the light of field experience and latest development in the state of the art technology was done. In addition to the above, the Signal Directorate has been rendering technical consultancy and advice on various problems arising on Zonal Railways.

**Telecommunication**

The main contributions of RDSO during early years say up to 1980 in the field of telecommunication which have led to improved communication, efficiency and safety are as under:-

- Developed loud-speaking telephones for Section Controllers and Single Push Button headquarter selective ringing equipment with gain of 10 to 15 dB in outgoing speech. This equipment was developed in collaboration with M/s ITI;
- Modified STC Way Station Selector for AC Electrified Section;
- Signal Post Telephone to minimize detention of trains due to the failure of signals;
- Development of Radio Patch Circuit which has improved the efficiency of Control Communication and train punctuality in the section;
- Extensive development of Microwave Communication Network;
- Development of telecommunication network in AC electrified areas for train traffic control circuits;
- Implementation of Microwave Network on IR;
- Design & development of 50V, 50 Hz signalling based control circuit and way station selector and headquarter equipment for AC electrified areas;
- Talk-back and paging system for marshaling yards;
- Development of VHF and UHF Equipment.

**Motive Power**

During fifties and early sixties, the Motive Power Directorate was involved extensively in solving the technical problems arising in manufacture of steam locos. Import substitution, fuel economy and service engineering measures like defect investigations and remedial methods were also pursued for the steam locos. Further, the directorate had been engaged in designs and standards works related with diesel-electric, diesel-hydraulic and electric locos since 1960s. Important accomplishment from this time, ranged from design of diesel-electric, diesel-hydraulic and electric locos, indigenisation of a large number of diesel loco components, establishment of special maintenance code in areas with reliability problems, evolving and adopting standards. The main contributions which have led to large scale adoption of diesel and electric traction on IR for improved reliability, speedy movement of freight and passenger traffic with increasing trailing loads during 1957-74 have been as under:-

- Prototype design of WT steam loco, which was manufactured by CLW;
- Modification to convert oil fired boilers for engines in place of coal;
Design of WCM5 DC electric loco manufactured by CLW;
- Design approval of WDM2, WDM4, YDM3, YDM4 and YDM5 locos from ALCO and GM;
- Design approval of WDS3 and ZDM2 locos of MAK Germany;
- Design approval of WDM3, WDS5 locos;
- Development of NG rail bus for Kalka-Simla section;
- Specification for 75 t BG steam breakdown crane;
- Designed WDS3, 600 hp class shunting loco fitted with O-C-O wheel arrangement;
- WDM4 class loco of 2600 hp having bogie equipped with primary and secondary suspension; New gear set of 57:20 introduced to increase speed up to 160 km/h;
- Tender specification issued for 1500 V DC electric freight loco;
- Indigenous development of filters for rail traction diesel loco;
- Maintenance schedules prepared for diesel traction;
- Design of 1400 hp WDM6 class loco;
- Assistance to CLW to manufacture 700 hp ZDM3, ZDM4 and WDS4 locos;
- Feasibility study to upgrade 2600 hp ALCO loco to 3600 hp;
- Design and development of high speed bogie for speed potential up to 160 km/h;
- Use of dynamic independent loco brakes during emergency braking;
- Torsional vibration to study the dynamic characteristics of the crankshaft;
- Re-power packing of WDM1 class loco;
- Successful development of indigenous paper filter for lubricating oil and fuel oil;
- Design to use indigenous cylindrical journal roller bearing in WDM2 class of locos in place of imported taper roller bearing;
- Indigenous development of Suri hydro-mechanical transmission for use on WDS4 class of shunting loco;
- Design of indigenous NEI roller bearings for front bogies of YD and WL steam locos;
- Application of traction motor type TAO 659 on WDM2 loco in place of existing 165 of HE (I) L make;
- Study of providing dual cabs on diesel locos by redesigning under-frame and revising equipment lay out.

Carriage

The Carriage Directorate has been bringing about improvements in coaches for safety, passenger comfort, increased capacity and higher speeds. For introduction of first Rajdhani Express, some modifications in ICF coaches were done so as to increase the speed without adversely affecting safety or comfort and oscillation trials were carried out for speeds up to 140 km/h. In seventies, Railway Board asked RDSO to examine feasibility of fitting air brake on passenger stock. Based on detailed study and trial, air brakes were first fitted on Mumbai-Delhi Rajdhani Express and it went into commercial service in June, 1982 on IR. The other important major activities of the Carriage Directorate for period 1957-76 are as under:-

- Development of all coil suspension for coaches;
- Introduction of A. C. Chair Car coach.
- Introduction of Rajdhani Express;
- Development of AC 2-tier Coach;
- Introduction of Composition brake blocks in EMU services.

Improvement of suspension systems, design of new type AC Chair Car and AC 2-tier coaches, introduction of composition brake blocks in EMU services have brought about considerable improvements in riding
comforts with more comfortable travel along with clearing coaching stock for high speeds for Rajdhani and Shatabdi trains.

**Wagon**

During pre-independence period, British firms M/s Rendel, Palmer and Tritton were providing design and development of freight stocks for IR. At that time nearly all the wagons were having low carrying capacity and low payload to tare weight ratio in the range of 1.09 to 2.64. Majority of the wagons were 4-wheelers and were fitted with plain bearings, vacuum brake system and screw couplings. The reliability of the stock was low along with high ineffective wagons and extensive maintenance requirements. The first major design development undertaken by RDSO in 1957-58 was for BG system and bogie type open BOX wagon was designed and developed for bulk movement of coal. This wagon with 25 t tare weight and has carrying capacity of 55 t but was working on vacuum brakes and fabricated bogies of steel plates. Presently, about 14,000 wagons are in use on IR. BOXT, BOBR and BOXE are BOX wagons with transition, screw and Centre Buffer Couplers (CBC) respectively and were introduced in sixties. In 1960, BOX wagon was designed with the provision of UIC bogie, roller bearings and center buffer couplers but the wagon was continuing with vacuum brake system and bogies were fabricated out of steel plates.

During 1980, a new high sided wagon named BOXN was introduced with air brake system, sealed type cartridge taper roller bearing and cast steel ‘CASNUB’ bogie. The wagon was also provided with high capacity draft gear and high tensile center buffer coupler. These designs were adopted based on then prevalent contemporary advances made in developed countries. BOXN wagon became the workhorse of IR for transporting the main commodities viz. coal, iron ore and many other consignments which can be loaded in open wagon and about 65,000 BOXN wagon are in use on IR.

The design of BOX wagon and BOXN wagon and their variants have enabled to transport more freight with higher payload to tare weight ratio with longer freight trains. The wagons have improved reliability.

**Electric Loco, Power Supply and EMU**

Electric traction was introduced in 1925 in India. This was 1500 Volts DC system. The 25 kV AC system was introduced in 1957, coincidentally the year in which RDSO was born. Considerable improvements had been done to improve reliability of power supply and indigenize the components to save scarce foreign exchange in Railway Electrification. The Electric loco has seen remarkable developments in terms of haulage capacity as well as reliability. The Electric Directorate has been constantly upgrading the locos to higher horse power with better operating efficiency. A brief of various freight and passenger locos of sixties and seventies is as under:-

**Freight Locos:**
- **WAG 1 (2900 hp):** Design from 50 Cycles European Group; Maximum Speed 80 km/ h;
- **WAG 2 (3260 hp):** Received from Hitachi, Japan; Maximum speed 80 km/ h; provided with silicon rectifier with Rheostatic braking;
- **WAG 4 (3150 hp):** Indigenously built, derived from WAG1 loco; Maximum Speed 80 km/ h; Silicon Rectifier with Rheostatic braking;
- **WCG 2 (4200 hp):** Maximum Speed 80 km/ h; Three axle tri mount cast bogie.
Passenger Locos:

- **WAM 1 (2870 hp)**: First AC Electric Loco on IR received from 50 cycle European Group and put into service in 1960; Maximum Speed 112 km/h; Two axle fabricated bogie, with Jaquemin Drive and pendulum suspension arrangement;
- **WAM 2 (2790 hp)**: Received from Mitsubishi, Japan in 1961; Maximum Speed 112 km/h; Bo-Bo fabricated Bogie;
- **WAM 4 (3400 hp)**: New Design Concept; Cast CO-CO Bogie of Alco design received with WDM 2 loco; Maximum Speed 120 km/h; Silicon Rectifier with Rheostatic braking.

The directorate has also been bringing about design and standardisation of Electrical Equipment and systems for EMUs, Metro Rolling Stock, Train Lighting, Air Conditioning and power supply related items of the coaches for better comfort, safety, reliability, efficiency and maintainability of electrical equipment. Several innovative changes in the design were done resulting in new designs of coaching stocks.

Metallurgy & Chemical

Main activities carried out by the M&C Directorate have been development of suitable metallic, non-metallic, polymeric, anti-corrosive coatings and lubricants. In addition, developmental work in respect of non-destructive testing of critical rolling stock and Permanent way components, re-conditioning of worn-out components, failure investigation of critical components and studies into fatigue and fracture behavior of materials has been carried out. The main activities during 1960-79 are as under:-

- Introduction of ultrasonic examination of rails and axles utilizing imported equipments and standardisation of the test procedure;
- Development of weld reclamation procedure for worn out wheels, points and crossings for service life of 15 GMT;
- Introduction of submerged arc welding process of structural steel;
- Development of procedure for reclamation/ reconditioning of axle oil, crank case oil, transformer oil etc.;
- Development of paints based on CNSL resin (13 patents were filed and patent rights granted);
- Indigenous development of ultrasonic equipment for detection of defects in rails and axles. Two sources developed resulting in complete import substitution of ultrasonic equipments as a result 100% equipments on IR are of indigenous origin.
- Establishment of Thermit Portion Plant for IR to achieve self sufficiency for portion manufacture and rail welding.
- Development of weld reclamation techniques for wheel burn/ scabs on rails, tie tamping tools and loco components; Studies into fatigue properties of 52 kg 70 UTS rails, Carriage and Wagon axles.
- Studies into wear characteristics of wheel versus rail;
- Rationalization of roller bearing greases for locos, coaches and wagons.

The above activities have led to better materials and reliability in maintenance including re-conditioning of worn-out components. This has led to considerable savings and helped IR for carrying increasing traffic.

Patents

RDSO has been doing remarkable work and a large number of patents were being obtained for new innovations particularly in M&C Directorate. As reported in the Research Designs and Standards Organisation Annual Reports for 1960-61, 1961-62 and 1962-63, a total of 20 patents
were obtained. This continued in subsequent years also. This indicates the innovativeness of the people working in RDSO.

**Psycho-Technical**

Main objective has been to increase job performance, job satisfaction and motivation of employees as well as prevention of accidents due to human lapses. In this perspective, the Psycho-Technical Directorate has been engaged in research studies on variables considered important for traffic safety so that phenomena of accidents causation could be understood. On the basis of information obtained through research, study programmes, which aim to reduce accidents induced by human factors, are developed and executed. The staff connected with safety of train operation is examined with psychological test programmes developed based on research. The activities have been helpful in reducing human failure and thereby leading to improved safety.

**Summary**

It may be noted from above that during the early years, RDSO continued with the research, design and standardisations with full zeal along with relocating its staff and officers from Simla and Chittaranjan to Lucknow. It expanded R&D activities along with increase in officers and staff strength. The infrastructure at the RDSO campus has been fully developed. All the design wings from Simla were shifted to RDSO, Lucknow by 1965-66 and lastly the M&C Wing was shifted from Chittaranjan during 1967-72. The R&D work done in the first two decades of RDSO have enabled to indigenize most of the materials and components for rolling stock and track etc. It enabled to carry three fold increase in freight traffic by IR. The 100 years old speed barrier was broken with the introduction of first Rajdhani in 1969 at a speed of 120 km/h without any additional expenditure on the track and bridges.

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**Dr M. Srinivasan has been Director General, RDSO for 5½ years from 23-9-68 to 23-3-74 which is the longest tenure of any Director General at RDSO. It was during his tenure that the First Rajdhani was introduced. He had great quality of leadership and inspired a number of officers with his own example to pursue higher studies and research. He was a voracious reader and has written several books including 'Modern Permanent Way' while working as DG.**

Once he told the author while he was working as Assistant Director (High Speed Bridges) that I want young people like you to go in for higher studies and research. This motivated me along with Dr N. Ananthanarayna, the then Dy. Director (B & S), Dr M. Mani, the then Assistant Director and some others to go for higher studies and obtain Doctorate. Dr Srinivasan not only asked us to work for Ph. D. but he himself worked for Doctorate and obtained Ph. D. in 1973. I recollect the day, when I came back after receiving Ph. D. from University of Roorkee, and received a personal nicely worded letter of appreciation from Dr Srinivasan delivered through his Private Secretary on 27-11-73. This speaks of his commitment to R & D.
Institutional Mechanism

General

The research areas are identified under the directions given by the Railway Board. The research projects also emanate from the traffic needs and field problems encountered by the Zonal Railways and Production Units. For this purpose, there are Governing Council and Central Board of Railway Research (CBRR) and Standards Committees for different disciplines. These institutional mechanisms are of vital importance to RDSO for setting technological missions and for identification and review of R&D projects. They also ensure coordination with other research laboratories, institutions and industry.

Governing Council:

The Governing Council came into existence in 1987-88 at the instance of Hon’ble Minister of State for Railways Late Sri Madhav Rao Scindia so that prompt decisions could be taken on technology missions and their implementation and also to provide highest importance to research. It is policy making body for RDSO. It comprises of Chairman, Railway Board as Chairman; and Financial Commissioner, Member Engineering, Member Mechanical, Member Staff, Member Electrical, Member Traffic, Additional Member (Planning)/ Railway Board and Director General, RDSO as its members. The functions of Governing Council are:-

- To identify and approve the R&D projects for technology development on IR;
- To review the progress of projects;
- To determine the quantum of direct investment in technology development within the overall allocation of funds under the plan head ‘Railway Research’;
- To give direction for improving the working of RDSO.

The 27th Governing Council meeting was held on 3rd November, 2006 at RDSO.

Central Board of Railway Research (CBRR):

Central Board of Railway Research (CBRR) consist of DG/ RDSO as Chairman, Addl. Member (Civil Engineering), Addl. Member (Mechanical Engineering), Addl. Member (Electrical), Addl. Member (Signal),
Addl. Member (Traffic), Advisor (Finance), Executive Director (E&R), Executive Director (Planning)/ Railway Board as members and Addl. Director General/ RDSO as member secretary. CBRR also consist eminent scientists, technologists, engineers and senior executive of other research organizations, academic institutions and industrial units related to railway technology and materials. The functions of CBRR are:

- To consider and recommend the programme of research of IR;
- To review the research programme from time to time;
- To ensure coordination and assistance from other research laboratories;
- To review the ongoing projects from the technical angle.

The 39th meeting of CBRR was held on 7th February, 2007 at RDSO, Lucknow.

**Standards Committees:**

The designs and standardisations are two of the main functions of RDSO. RDSO provides Design Codes, Manuals and Specifications along with Standard Designs and Drawings for all important fixed assets and rolling stock. Technical Standards Committees examine new designs, standards, specifications and studies done by RDSO for effective adoption on IR. There are separate Standards Committees for different disciplines for deliberating and giving recommendations on all technical matters concerning designs, construction/ manufacture, maintenance of fixed assets and rolling stocks. These deliberations go a long way to finalize, amend, update and approve Design Codes, Manuals, Specifications and Standard Designs. Director Standards/ Executive Directors of RDSO of the concerned discipline are the member secretary of the committees and make agenda including technical appraisal of the issues and finally draw the minutes of the meetings which are usually held once a year. Sometimes additional special committee meetings are held to decide
urgent and/or specific issues needing more detailed considerations. These committees are very useful for technological upgradation of IR. Minutes of the meetings give lot of insight into the thought that has gone for the technological upgradation of the railways and also throw light as to how field problems have been solved. Some of the Committees were started even earlier to CSO. In 1958, there were following Standards Committees-

- Bridges and Structures Standards Committee;
- Track Standards Committee;
- Signalling and Interlocking Standards Committee;
- Locomotives Standards Committee;
- Carriage and Wagons Standards Committee; and
- Electrical Standards Committee.

At present there are following Standard Committees:

- **Track Standards Committee (TSC):**
  In 1924, Railway Board constituted Standing Committee consisting of Chief Engineers of all the Railways with the main aim of standardizing the essentials of permanent way and bridges along with two sub-committees one for track and the other for the bridges. One officer of the RB was appointed as the permanent secretary of the Sub-Committee. First sub-committee for track met on 18th February, 1926. The Standing Committee consisting of Chief Engineers was, however, abolished by the Railway Board in June 1926. A Track Standards Committee was set up by the Railway Board with technical officer of the Railway Board as Permanent Secretary and members of the committee were of the rank of Deputy Chief Engineers.

In 1968, RB made all Chief Engineers as members of TSC with Director Standards (Civil), RDSO as member secretary. Subsequently CTEs of the Zonal Railways were made the members in place of the Chief Engineers and Director Standards (Track) now designated as Executive Director (Track), RDSO, as member secretary. Present composition of the committee consists of all CTEs of the railways, Director/IRICEN/Pune, Executive Director (Track Machines), RDSO, as members with Executive Director (Track) as member secretary. It has one observer each from Metro Railway, Kolkata; MRVC, Mumbai; RITES; IRCON; KRCL and RVNL. So far TSC have had 77 regular meetings and 8 extraordinary meetings to discuss issues of extreme importance.

- **Bridges and Structures Standards Committee (BSC):** Bridges and structures standards committee has been working since 1924 and so far generally BSC meetings have been held each year with some special meetings for deliberating on important and/or urgent issues. All Chief Bridge Engineers of Zonal Railways and Professor Bridges, IRICEN, Pune, are the members of the Committee with ED (B&S), RDSO, as member secretary. The last 76th BSC meeting was held in 2007 at Lucknow.

- **Works Standards Committee (WSC):**
  The committee was separated from Bridges and Structures Standards Committee in 2005 and all Chief Engineers (General)/Chief Planning and Design Engineers are the members of the committee with ED (B&S), RDSO, as member secretary. Its 2nd meeting was held in 2006 at Shillong.

- **Signal Standards Committee (SSC):**
  Signal Standards Committee has all CSTEs of all Zonal Railways as members with Sr.
ED (Signals) as member secretary. The last 79th SSC meeting was held in February, 2005 at Bangalore.

- **Telecom Standards Committee (TCSC):** The committee is instrumental in standardisation of specification of telecom equipment and gives recommendations on all significant issues concerning telecom requirements of IR. Its sub committees have submitted several useful reports on various subjects like VF communication on 4 Quad/6 Quad cable, multi-channel plan and frequency plan for MW link on IR. Last 33rd TCSC meeting was held in February, 2006 at Chennai.

- **Locomotive Standards Committee:** The first Locomotives Standards Committee meeting was held on 8th to 11th June, 1928 at Simla and was held yearly till 1995. It has all Chief Mechanical Engineers as Members and Sr. ED (MP), RDSO as member secretary. The last meeting was held at Baroda House, New Delhi, in November, 1995. Now further meetings are not being held as most of the functions are being looked after by Diesel Maintenance Group.

- **Diesel Maintenance Group:** With introduction of diesel electric locomotives in IR, necessity was felt to have a committee to deal with the maintenance problems of these locos. Accordingly Diesel Maintenance Group was set up which held its 1st meeting in Chittaranjan Locomotive Works on 11th September, 1958. It has all CMPE (Diesels) as Members and Director Motive Power as Secretary. Sr. ED (Motive Power) also attends the meetings. This meeting is held regularly and the last 40th meeting was held in January, 2007 at Aurangabad.

- **Carriage Maintenance Group (CMG):** Locomotive and C&W Standards Committee was functioning since 1924. In 1979, a C&W Maintenance Group was formed by RB which held its first two meetings in 1979 & 1980. A separate Carriage Maintenance Group was formed by Railway Board in 1996. The convener of CMG is EDS (Carriage), RDSO. All CRSEs of Zonal railways, CWMs of all major carriage workshops, Sr. DMEs of major Carriage Depots, CMEs/ CDEs of ICF & RCF, Director/ CAMTECH, Gwalior and EDIL, RDSO are members. Last 10th CMG meeting was held in February, 2005 at Coonoor.

- **Wagon Maintenance Group (WMG):** Earlier Carriage and Wagon Standards Committee existed which was bifurcated in 1995 into two maintenance groups separately for carriage and wagons. The last meeting of Wagon Maintenance Group was held in 2004.

- **Electrical Standards Committee (ESC):** The committee has been functioning since 1935. Chief Electrical Engineers of Zonal Railways, Production Units, CEE/ Metro, Kolkata, Sr. ED (TI) and EDPS and Director, IREEN are members and Sr. EDSE, RDSO is the member secretary of the committee. 54th ESC meeting was held in March, 2006.

- **Electrical Maintenance Study Group:** Electrical maintenance study group was set up by the Railway Board and has been functioning since 1968 with Sr. DEE of Electric Loco Sheds, CELEs of Zonal Railways, Director (Rolling Stock), Railway Board and Director Standards Electrical as member secretary. Last 31st meeting was held in September, 2006.

- **Metallurgical and Chemical Research Sub-Committee:** The committee was constituted in 1960 with Dy. CCMTs & CMTs of Zonal Railways and ED (M&C), RDSO as member secretary. The last
meeting of the sub-committee was held in 2003.

- **Traction installation maintenance Study group** was set up by Railway Board with Sr. DEE/ TRDS, CEDEs of Zonal Railway, Prof. TRD IRIGEN/ NASIK as member and Director/ TI/ RDSO as memebr secretary. The last meeting was held in 2006 at Vishakhapatnam.

  The functions of the Standards Committees have been of vital importance for sorting out the problems of Zonal Railways and Production Units. These have been helpful in providing updated Designs, Codes, Manuals, Specifications and Guidelines for construction and maintenance of Track, Bridges, Signalling, Telecommunication, Locomotives, Carriages, Wagons and Electrical etc. for design, construction, manufacture and maintenance of Railway assets. These Standards Committees assist in finding suitable appropriate solutions to field technical problems.

  The institutional mechanism has been of vital importance in steering the RDSO on the correct path for powering the growth of IR.
Breaking The Speed Barrier:  
The First Rajdhani

Introduction

Breaking the speed barrier of the past 100 years, the first Rajdhani Express started running at 120 km/h from 1st March 1969 between New Delhi and Howrah. It was covering a distance of 1445 km between New Delhi and Howrah in about 17 hours, 20 minutes with three stoppages at Kanpur, Mughalsarai and Gomoh. This is a milestone in the history of Indian Railways.

In 1960, keeping in view the world trends, Railway Board decided that a systematic study should be conducted by RDSO with a view to achieve progressively increased speeds on its Railway system. The maximum operating speed on BG had been limited to 60 miles/hour (96 km/h) for about 100 years on IR. The priority in this matter was given to BG, which carried the bulk of traffic. A target of 160 km/h for passenger traffic and 100 km/h for goods traffic with an intermediate stage of 120 km/h for passenger traffic was laid. Extensive investigations and research were commenced from 1962 and continued.

Sri K. C. Sood, the then Member (Engineering) and earlier DG (RDSO) vide his D.O. letter No. 67/ WSC/ TK/ 5 dated 16.10.1967 addressed to DG (RDSO) (Annexure-II) sent a note of discussion regarding ‘Introduction of a speed of 120 km/h on the Delhi-Howrah route’, ordering RDSO to take-up the feasibility study as indicated in the note as expeditiously as possible. It also stated that a team of senior officers should be nominated and placed on special duty for this project. He further observed that diversion of capacity to this special project would mean postponement and slowing down of certain other projects now in progress with RDSO. The letter and the record note of discussions indicate the urgency of the matter and the depth in which it has been gone into by Sri K.C.Sood, the then Member (Engineering) and earlier Director General, RDSO.

Immediate action was taken by all the wings of the RDSO and after in-depth study a detailed note covering all aspects of train operating at speed of 120 km/h on New Delhi-Howrah route were examined and explained to the Board vide Sri T.V.Joseph, the then Dy. Director General, RDSO’s Note No. DDG/ Misc/ II dated 2nd February 1968. Thenote is contained in Civil and Mechanical Engineering Report No. C&M-1 of Research Designs and Standards Organisation, Ministry of Railways, Lucknow, on ‘Increase of Speed on Delhi-Howrah Route Feasibility Study’ printed in May 1969. The C&M-1 report of RDSO which is in two volumes, gives detailed account of R&D work done by RDSO to arrive at decisions regarding various aspects for introduction of Rajdhani Express. The note of Sri T.V.Joseph dated 2nd February 1968, covered safety, economics, customer satisfaction, realism (implementation without too much delays), scope, targets and indication of earlier research regarding strength and structure of the track; fish-plated rail joints; effect of speed on track stresses; vehicle performance on track; rating and performance of Motive Power; brakes and braking distances; signalling; increased speeds over curves; strength of bridges; and maintenance of track. It would be interesting to read the note for knowing the depth of consideration. The note clearly brought out the technical work already done after the
receipt of the Board’s letter and suggested further course of action. After detailed analysis, the note concluded as under:

**“Increase of speed-feasibility**

The work undertaken by the RDSO over the past few years and particularly the intensive investigations, testing, research and study undertaken in the few months have shown that it is possible to achieve moderately higher speeds of the order of 120 km/h to 140 km/h, on our trunk routes and main lines, utilising existing track, bridges and rolling stock. A higher standard of maintenance of track and rolling stock has to be ensured, for achieving such increase of speeds.

**Increase of speeds-economic considerations**

From the data presented in the earlier paragraphs, it can be seen that the introduction of moderately higher speed on our trunk routes and main lines can be achieved, without any additional initial expenditure and without any increase in the maintenance and operating costs. In fact, in the case of track and rolling stock, the exercise of introduction of a few high speed trains on a route, would result in overall savings in maintenance costs and also in cost of replacements. Increase of speeds is also expected to bring other economic advantages, from the commercial and transportation aspects.”

RDSO recommendations were positive and clearly reflect the commitment and desire of the R&D team to introduce higher speed to break the speed barrier. The Railway Board accepted the recommendations of the RDSO in June 1968 that an increase of speed on Delhi-Howrah route was possible without any large scale capital investment on track, bridges and signalling, by utilizing the existing locomotives and coaches. Proving trials with test rake and subsequently with prototype rake comprising of WDM4 loco and all coil ICF coaches were done on the entire route between Delhi to Howrah once a month for eight months. The Rajdhani Express started running from 1st March, 1969.

Dr. M. Srinivasan, the then Director General, in his article entitled “Ushering in Higher Speeds on the Indian Railways” in Indian Railway Technical Bulletin’s special issue on ‘Rajdhani Express’, Vol. XXVI, No. 175 of November 1969, has explained the significant aspects which led to successful introduction of Rajdhani Express. His explanation is interesting and explains the philosophy and also the technical aspects and is given below:

**“Planning for higher speeds on the IR**

The impact of speed is multi-dimensional. Its effect, especially in the higher ranges, on the various parameters of rail-traction is very complex and incompletely understood. Therefore, planning of higher speeds calls for a high degree of coordination in the activities of a high speed project. The major activities can thematically form several work-packages for exposition via a hierarchical series of networks to project the various tasks entrusted to discrete groups of technicians and also the interfaces that determine the degree of synchronization required between dynamic field testing, static laboratory testing, design development, manufacturing activities in the Integral Coach Factory, etc.”

**A non-doctrinaire view of high speed track:**

For ages it was considered incontrovertibly logical that higher speeds should impose heavier loads on track and should accordingly need heavier rails.
Worldwide experience adduced further proof to such thinking, as strengthening of track-structure was to be associated with higher speeds. Researches made in the past on the IR also led to the conclusion that higher speeds resulted in an increased impact augment. For over four decades, these very considerations proved an effective deterrent to breaking the speed barrier of 100 km/h, for the IR could ill-afford the large scale upgradation of track-structure on any of its important routes.

It was decided to investigate de-novo the effect of higher speeds on track-stresses. These researches indicated that improved maintenance of track could more than offset the increase in stresses in the track on account of higher speed. Thus, the focus of attention shifted from strengthening of track to track geometry.

Vertical and lateral oscillations, spring deflections, bolster swing and bogie rotation of the loco and coaches and also the lateral forces recorded at the axle box of the loco were recorded together with track irregularities. These results were painstakingly analysed to derive correlations between the oscillations of WDM4 diesel-electric locos and ICF all coil coaches on the one hand and the track irregularities on the other. Service tolerances for maintenance of track were established and the criteria for the design of curves evolved to ensure internationally accepted standards of riding comfort and safety. The requirements of track geometry for operation of 120 km/h were intimated to the maintenance engineers of NR and ER on New Delhi-Howrah route. They were helped to bring up the track to the required standard of maintenance by improved techniques including ‘Measured Shovel Packing (MSP)’ and ‘Directed Track Maintenance (DTM)’.

Periodical track recording was done and oscillation trials carried out for location of defects and to establish that the track could be maintained to the required standard over a long period.

Assessment of the unevenness of longitudinal level of rail and the inadequacy of packing under sleepers has traditionally been a matter of the gang mate’s judgment and experience. MSP is a scientific approach to remedy this disadvantage without calling for sophisticated mechanical appliances, which seek to rectify the unevenness of longitudinal level and provide the correct super-elevation by spreading layers of appropriate thickness of stone chips under the sleepers. The title ‘MSP’ is derived from
the fact that certain simple measurements are required to estimate the quantity of chips and that shovel are used for spreading these chips by way of packing. It is a passive mode of packing.

DTM, which is need-based rather than time-oriented, aims to conserve the maintenance effort by deploying it only to the requisite extent as determined by a more intensified examination of track. Thus, well consolidated track is left undisturbed with the result that this system yields improved track performance as well as overall economy in maintenance costs.

Intensive research and physical trials were carried out over curved track and bridges. The increase in speed had to be restricted to a level up to which extensive changes were not required in the alignment of curves which would, in most cases, involve appreciable expenditure and disturbance to consolidated track.

Least cost sub-optimization: Once the contra-indicative expenditure on track strengthening is obviated, the path became clear for undertaking sensitivity studies aimed at locating those features which:

- Reflect a highly predictable beneficial influence on the performance characteristics; and/or
- Reduce the uncertainty of behaviour resulting from changes in the parameters analysed.

Optimization presupposes the simultaneous maximization of certain important objective functions, but in this case sub-optimization was resorted to as only one high speed train was visualized to operate. Thus, in the time cost utility analyses, sub-optimization was meaningfully geared to provide emphasis on least cost solutions that can be put into operation in the quickest possible time. To illustrate, the inter-signal distances were left unaltered, improved braking efficiency having been obtained by incorporating certain simple devices innovated by the RDSO.

Likewise, standard integral coaches with all-coil bogies were used, with very minor modifications relating to prevention of oil-leakage in the dashpots and rigorous and more frequent inspection of running gear.

Coach-work was modified to provide for greater storage of water necessitated by longer inter-stop hauls, and “snack-table” was attached to the back rest of chairs for taking meals. A separate drinking water tank was added for the first time, with two water-raising apparatus. A stand-by generator was provided to strengthen the air-conditioning system, and a pantry-car was specially designed for storage of pre-cooked food, beverages, etc.

Proving trials and safety

Safety brooks no excuses, and in matters affecting safety nothing is so trivial that it can be overlooked. Extensive proving trials were undertaken firstly to determine the maximum speed that could be safely and confidently introduced on the New Delhi-Howrah route via Gaya. It would, for instance, be purposeless to propose a particularly high speed if test-results indicated that this speed could be attained on but a small part of the route under the prevailing conditions of track-maintenance. Wisdom lies essentially in making an effective compromise; in this case the comparison is between introducing a maximum speed of 120 km/h straightaway and waiting a few years bringing up the maintenance standards of track and rolling-stock so as to introduce yet higher speeds.

RDSO’s recommendations were to raise the maximum speed from 100 to 120
km/h, the resultant 20% increase obtainable at virtually marginal capital outlay. To reckon with personal equation in the judgment of drivers, especially at high speed, and also to provide adequate safety margin, these trials were conducted mainly at speeds varying up to 136 km/h, although speeds up to 150 km/h were successfully attained without creating any feeling of discomfort.

**The Shadow Express**

On the rail roads of advanced countries, train-scheduling is done with the help of computer; 2 programmes, FAST (Formulae for Assessing the Specification of Trains) and FRATE (Formulae for Routes and Technical Equipment) are in use in the USA for optimal scheduling of trains taking into account the physical constraints. In keeping with the times, therefore, an Amsler Train Schedule Computer was used to time-table the Rajdhani Express, taking into consideration the curvature compensated gradients, acceleration characteristic of the loco, and the residual speed restrictions. Based on a close study of the control charts, the desiderata relating to the convenient timings at the two termini, and the output of the Train Schedule Computer, the final timings were derived, to which a “Shadow Express” was run at regular intervals of time to verify the practicability of the final schedule.

The main purpose of running the shadow express was to check and recheck upon the visibility of signals, and to provide valuable prior-experience of the stresses and strains imposed by the high speed train on the alertness of gateman at level crossings, the “block operation” at the various stations on the route, etc. The perceptual and subjective experience gained thereby by drivers and guards, station masters and cabin-men, gatemen and gangmen was meant to acclimatize and attune all of them to the rigours and discipline necessitated in running a high speed through train that has three stops and which travels at a speed 20% greater than any other train on the route. These rehearsals also provided the data necessary for the appropriate stipulation of periodic schedules for the inspection and maintenance of the under gear of rolling stock, etc. An unready mind, it is said, controls an unsafe hand, and the in-service training provided a healthy format for identifying and remedying the operational, maintenance, organizational and human problems, so that safety is fully guaranteed well before the due date for inauguration of the Rajdhani Express.

**Cost and retrospective assessment:**

The total cost of the high speed project culminating in the inauguration of the Rajdhani Express works to about Rs. 115 lacs, of which Rs. 91 lacs accounts for the new air-conditioned rake, and Rs. 14 lacs for Signalling and Telecommunication work at certain stations on the selected route and in the new rake for public address system, wireless reception, playback on prerecorded music via tapes, etc. Applied research and testing trials each account for about Rs. 5 lacs.

The Rajdhani Express provide a vivid imagery, as it flashes past, of what imaginative and well-directed research can achieve in a short period of time and at little extra cost. In essence, the running of Rajdhani Express may be described as an act of faith, of confidence in the efficiency and dependability of the thousands of railway-men who work all along the route. As a result of the improved maintenance function, the track components would have a longer lease of life, and the wear and tear of the rolling stock plying on the route would also reduce. The increased
awareness for attaining better standards of maintenance, both the track and rolling stock, and the resulting benefits would not have been, in retrospect, possible to achieve but for the inspiring goal provided by the Rajdhani Express.’

The above article of Dr. Srinivasan has covered most of the important aspects. However, it would be interesting to know about R&D inputs regarding ‘Braking and Signalling’ and also to know about ‘The train composition and the facilities’, as were provided in the Rajdhani.

**Braking and Signalling**

Train operation on the IR is essentially based on the automatic vacuum brake system. Air brakes are used only to a very limited extent in special cases, such as in new types of motive power and electric multiple units. It would have proved an economic deterrent to the introduction of higher speeds, if such introduction had to be based on any system of brakes other than the automatic vacuum brakes. Extensive investigations, research and tests were, therefore, conducted on the automatic vacuum brake system, aimed at improving its performance. A full-scale vacuum brake engineering research and development laboratory was set up for this purpose in the RDSO. This Lab had provision to simulate the braking action of trains up to 1,200 meters in length, when fitted with various types of equipment. In addition, tests were conducted also on the running track. As a result of these studies, it had been possible to improve the capability and dependability of automatic vacuum brake system, by fitting direct admission valves, redesigning of various components permitting streamlined flow of air through the brake pipe and modifying link ratio. It had been proved that higher speed trains fitted with automatic vacuum brake system to the improved design can be brought to a stop, within braking distances comparable to those required for controlling trains without these improvements, operating at lower speeds.

The Railways use a number of types of signalling systems on its trunk routes and main lines. A large scale change in the signaling system was physically and economically not possible as a prerequisite for the introduction of moderately high speeds. Under the circumstances, it was decided that the present increase of speeds should be only to such limits as would permit braking distances for the higher speed trains with brake improvements, being kept within those for the lower speed trains without brake improvements.

To provide extra warning to the driver, the Warner signals at ‘B’ class stations have been advanced and placed on separate posts ahead of the first stop signals. Due to the increased distance from the station, these are electrically operated.

**Train composition and facilities:** The Rajdhani Express offers fully air-conditioned sitting or sleeping accommodation in dust-proof, noise-free all-vestible slumberette chair cars or deep-cushioned sleeper coaches, with well-appointed interior, light folding tables as in aircraft in front of the chair car seats and also a public address for relaying music, news and other announcements. The ticket issued for the journey on the train is inclusive of the cost of meals, served to the passenger at the seat. The coaches for the Rajdhani had been manufactured in the Integral Coach Factory, Chennai. The rakes of the train consisted of four to five chair cars, one sleeper coach, one pantry car-cum-lounge and two power generating cars with luggage compartments.

The shells for these coaches were of the standard all-steel, all-welded, integral
light-weight construction with anti-telescopic ends. The coaches had been fitted with improved brake equipment and roller bearings. The bogies were of the standard ICF design and coiled springs for primary and secondary suspensions, vertical shock absorbers and hydraulic dash-pots in the axle guides and silent block rubber mountings for better riding comfort. The coaches had been specially insulated on the roof and sides with a layer of sprayed limpet asbestos and thermo-cole slabs. Sprayed asbestos had been used below the timber floor also, to provide for thermal as well as sound insulation. The air-conditioning equipment permits electrical heating being automatically switched on during cold weather.

Each chair car had 73 seats, five seats being arranged in each row on either side of a central aisle. Wide windows offer a panoramic view of the countryside, as the train rushes past, while matching curtains help cut out direct sunlight, when required. Arranged at the ends of the coach are four toilets besides an alcove for cool drinking water. The ‘chairs’ are upholstered with moulded foam rubber seats and special expanded vinyl. An air-conditioned pantry car had been provided on the train for the first time on the IR. Electrically operated kitchen equipment included toasters, hot cases, bottle and water coolers and deep freeze cabinet for ice-cream. Food prepared in base establishments is picked up at starting or halting stations and stored hot or cold, as necessary. It is possible to prepare tea, coffee and snacks in the pantry car itself. Attached to the pantry car is a small lounge for the sleeper coach passengers who can relax, play cards, discuss business, or read magazines in the homely atmosphere. The lounge is elegantly furnished with comfortable sofa, carpets and curtains while subdued lighting adds to the décor.

Two power-generating cars, one at each end, had been provided for generation of power to operate the air-conditioning units, lights, fans and the kitchen equipment. Power was generated at 440 Volts AC and was fed to each coach through interconnecting coach couplers. The power was, stepped down to 110 Volts for lighting purposes while the air-conditioning equipment works at 440 Volts. In case of failure of the power supply, there is provision of 24 Volts emergency lighting arrangement in each coach, current being fed from storage batteries located under each coach.

The Rajdhani is the culmination of a ceaseless effort of hundreds of Railway officers and men. In the wake of hectic activity in laboratories, on track, in workshops and in offices, introduction of the train marks the fruition of their zeal and dedication. It has been beginning of an era of high speeds on Indian Railways. A number of Rajdhani, Shatabdi and Garib Rath trains are now running at speeds between 120 km/ h to 150 km/ h. The Shatabdi Express between Delhi and Agra has been running at a speed of 150 km/ h. RDSO continues powering the growth of IR.....

Sri T. V. Joseph has been most popular Officer with excellent leadership qualities. It was during his tenure as Dy. Director General and Director (Research) that the first Rajdhani was introduced. He contributed to it a lot as will be evident from his detailed and extremely positive note for introduction of the Rajdhani given in C & M - I report of RDSO. Under his dynamic leadership a lot of R & D work has been done particularly in track. He was Director General, RDSO from 19-5-74 to 26-2-76.
It may be noticed from above that IR has been carrying more than nine fold traffic with only about 42% increase in running track-km with the same number of locos, wagons and only 2.83 times increase in coaching stock. This is a remarkable achievement and has put heavy pressure on track and bridges which are subjected to six to eight times more GMT/ annum.

The 100 year old speed barrier of 60 miles/ hour (96 km/h) was broken by introduction of first Rajdhani Express between Delhi and Howrah on 1st March 1969 at a speed of 120 km/ h. Now a number of Rajdhani Expresses and Shatabdi trains are running on IR with speeds up to 150 km/ h. Indigenous technology for speeds up to 160 km/ h is available with RDSO. Passenger comfort has also been increased with better riding qualities and improved interior designs of coaches etc. The safety of the passengers has been improving year by year. The train accidents per million-tonne-km, an important index of safety, has dropped to 0.29 in year 2004-05 from 0.64 during year 2000-01 (Indian Railway’s Year Book 2004-05, p-71).

In pre-independence period, locomotives, coaches, wagons were designed by British firms and were imported. Design of all important bridges, rails and track components etc. was also done in UK and the material used to be imported. It was a big drain on foreign exchange. RDSO through sustained R&D efforts developed alternative indigenous materials and designs with improved efficiency. Now all designs for rolling stock including locos, bridges and rails including track components are developed in India and produced by indigenous material effecting substantial improvements in the quality.

### Revenue earning freight

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### Non-suburban passengers

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### Year Running track km

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<th>Wagons</th>
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<td>84,260</td>
<td>7,910</td>
<td>222,379</td>
<td>37,119</td>
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RDSO for IR

The story of RDSO tells as to how RDSO has been working behind the IR for handling such phenomenal increase in traffic along with running a number of Rajdhani, Shatabdi and Garib Rath trains at speeds up to 150 km/h with better passenger comfort and improved safety. It also explains how self-sufficiency in all matters of track, bridges, signalling and telecommunications, locomotives, wagons and coaches etc. have been possible with technical inputs provided by RDSO.

The work done during the past fifty years by RDSO has enabled IR to attain these achievements. RDSO has a number of laboratories, which are well equipped with research, and testing facilities for development, testing and design evaluation of various railway related equipment and materials etc. It also possesses mobile test facilities for recording of track parameters, loco motive power and conducting oscillograph trials for evaluating vehicle track interaction and also monitoring track conditions. It also possesses High Speed Track Recording Car, High Speed SPURT Cars for rail flaw detections and is now building its own test track. Its all directorates are fully computerised and have latest design softwares for designing of rolling stock, bridges and structures and rail wheel interaction studies etc. The activities of various technical directorates leading to improvements have been given in Section-II of the book. The major problems encountered and overcome by RDSO are briefly mentioned below.

Bridges

IR has 121,295 bridges out of which seventy percent bridges were constructed in nineteenth and early twentieth century for lighter loads and are thus more than 100 years old and have outlived their codal life. They had been constructed when axle loads were light and there was no provision for tractive and braking forces which was introduced in 1926 through IRS Bridge Rules. There was problem of fatigue due to aging. Due to increase in traffic, axle loads have been increased along with increase in longitudinal forces (traction and braking), first by introduction of RBG loading in 1975 and then by MBG loading of 1987 with 25 t axle load and trailing load of 8.25 t/ run meter. This is being further increased for heavy mineral loading of 30 t axle load with a trailing load of 12 t/ m on selected routes. These changes have put tremendous pressure on bridges. It was essential to investigate all types of bridges for various spans to ensure that they are safe for the proposed loads and speeds. Even failure of one bridge can cause a catastrophic disaster. Impact Factor in IRS Bridge Rules had been specified for speeds up to 100 km/h based on trials by trains hauled by steam locos. Effect of dynamic loading was to be determined for diesel electric locos running at higher speeds up to 140 km/h for introducing the first Rajdhani Express. The provision of dynamic augment has been revised based on trials and study in IRS Bridge Rules. Effect of increased tractive and braking forces on bridges was studied. Extensive instrumented trials on several bridges have been done. A theoretical method for working out ‘Dispersion of Tractive and Braking Forces in Railway Bridges’, taking into account elastic deformations and slips at rail girder interface and bearing level of all bridge components and rails in track and approaches was developed by the author. Based on the theoretical method LFDISP programme has been developed as a technical paper of RDSO. B&S Directorate has been providing consultancy to all Zonal
Railways for their bridges and structures problems. It may be appreciated that by continuous R&D efforts trains with increasing axle loads with increased traction and braking power over 100 years old Railway bridges designed for much lighter loads have been carrying traffic safely.

**Track**

The track on an average has been called upon to carry more than six times GMT/year due to increase in traffic. The track in fifties and sixties essentially comprised of lighter rails up to 90 lb/y on wooden/ CST-9/ ST sleepers with rigid fastenings such as dog spikes, round spikes. The rails were 12 to 13 m long with fish plated joints. They were not suitable for higher loads and heavy density of traffic. Investigations were done by RDSO to study the track by research and tests. At first, as described in Chapter-3 ‘The Early Years’, appropriate technological changes based on study and research were introduced. It was realized that better track geometry is very important for longer track life and to reduce wear and tear of rolling stock. The track geometry was improved by Directed Track Maintenance and Measured Shovel Packing. With better attention to rail joints, along with the growth of the traffic, weak links were identified by field and lab measurements and fatigue trials and remedial measures were taken. A better maintained track enabled running of trains at higher speeds. These changes enabled IR to introduce first Rajdhani Express between New Delhi and Howrah in 1969. Simultaneously R&D was going on to redesign the track for increased loadings with state of the art technology being adopted in advanced Railways abroad. New type of heavier rails first 52 kg/m rail was designed by RDSO in 1959 and then subsequently 60 kg/m have been used. The rail strength has also increased from 72 to 90N/mm². RDSO has designed PSC sleepers which have replaced wooden/ CST-9 and ST sleepers and now about 10 million/year PSC sleepers are being put into the track. These sleepers are provided with elastic fastenings developed by RDSO. Long Welded Rails (LWR) and Continuous Welded Rails (CWR) are being extensively used. Several other improvements have been brought out in the track by the Track Directorate.

Earlier the track maintenance was done manually but due to modern track with PSC sleepers with elastic fastenings and LWR/ CWR, mechanized maintenance of track has become essential. There are about 500 track machines of different types on IR. RDSO provides technical support for these machines. The track monitoring system along with ultrasonic testing of rails has enabled to maintain track safely even with increasing speeds and loads. This is being looked after by Track Machines and Monitoring Directorate.

**Geotechnical Problems**

It has been providing technical support to all Zonal Railways for all types of geotechnical problems including foundation design and formation, track ballast etc. RDSO has extended its technical expertise for improving designs of Railway formations for higher speeds and heavier axle loads besides solving geotechnical field problems especially of weak formations. It has introduced latest technology to achieve objectives with economy for improved quality of constructions. The work is being done by Geotechnical Directorate.

**Signalling & Telecommunication**

In the sixties, a large number of designs of signalling equipments were in use on
Indian Railways. RDSO successfully completed the task of standardizing the design of mechanical and electro-mechanical signalling equipments such as Analog axle counter, IRS point machine, axle counter block, Universal Fail Safe Block Interface equipment and introduced the signalling relays, under ground signalling cable, signal lamps, roundels, lenses and other fittings, point machines, track circuit components etc. LED signal lamps have been developed in coordination with Traffic Directorate as a replacement to conventional incandescent bulbs used in colour light signals. This is a breakthrough in signal lighting technology, as it offers a longer life of 10 years as compared to 3 months for a conventional bulb. There have been major changes in the field of telecommunication and notable work has been done by RDSO in the field of Optic Fiber Communication system, DMTF Train Traffic Control system and VHF Communication system. These are some of the contributions of Signal and Telecommunication Directorates of RDSO.

**Diesel-Electric & Electric Locos**

Demands on IR have been changing with growth of freight and passenger traffic. A quantum change in technology was required to meet the growing needs of the industry for transport of coal, ores, steel, mineral, oil etc. RDSO took up the challenge and the technologies for manufacture of locos at DLW & CLW were identified and absorbed for production of indigenous diesel-electric and electric locos. Steam locos have been gradually phased out and diesel-electric and electric locos with quantum jump in their traction power have been introduced in adequate numbers. These locos are more fuel efficient, reliable with more efficient controls. RDSO has been assisting DLW & CLW in absorbing the world-class technology with appropriate changes to suit Indian conditions. Diesel-electric and electric locos suitable for passenger, freight, shunting etc. with RDSO’s designs along with lot of improvements have been introduced. Diesel-electric locos up to 4000 hp have been designed by RDSO. WDG4 and WDP4 of 4000 hp can exert tractive force up to 53.0 t are suitable for high trailing loads and at high speeds. RDSO has also designed diesel electric locos which have been exported to Bangladesh, Malaysia, Vietnam, Sri Lanka, Angola and Sudan.

Electric locos have seen remarkable developments in terms of haulage capacity and reliability. They are carrying 63% of BG freight GTKM and 47.5% of passenger train kilometers on about 27% of route kilometers of IR which are electrified. In sixties and seventies, the designs of existing freight and passenger locos were improved and locos were designed for higher horse power and for higher speeds suitable for running increased trailing loads. In nineties WAG9 and WAP7 locos with 6120 hp and 6000 hp for freight and passenger traffic respectively, were imported from M/ s ABB, Switzerland with transfer of technology. WAP5 loco had the latest state of the art technology with air and regenerated braking, GTO based propulsion system, Bo-Bo flexi float bogie, 3-phase squirrel cage induction motor and is capable of running up to 200 km/ h. CLW has fully absorbed the technology and RDSO has designed an improved version WAP7 loco with 6000 hp suitable for IR conditions. The cost of indigenously manufactured loco has come down to Rs. 9.5 crores against the original cost of Rs. 22 crores of imported WAP5 loco. These locomotives have enabled to carry increasing trailing loads up to 5000 t for freight trains and to run passenger trains up to 160 km/ h. The locomotives designed...
in nineties and later are much more fuel efficient and reliable.

**Wagons**

In fifties and sixties mostly four wheeler wagons with vacuum brakes, plain bearings and screw couplings were existing on IR. They were not suitable for high speeds and their load carrying capacity viz-a-viz tare weight was not much. The eight wheeler BOX, BCX, BRH wagons having centre buffer coupler, roller bearing, UIC bogies, vacuum brake and axle load capacities of 20.3 t were developed in the sixties and seventies. This was a quantum improvement over the four wheeler plain bearings and screw couplings type of stocks with axle load of 16.3 t inherited by IR. These have higher payload to tare weight ratio and are therefore more economical. The bogies are more reliable and suitable for higher speeds.

RDSO further developed BOXN, BCN, BTPN, BOBR & BTPGLN wagons with cartridge taper roller bearing, high tensile centre buffer coupler, high capacity draft gear, air brakes, cast-steel CASNUB bogie with elastomeric pad and improved track load density for transporting heavy and special size consignments. New designs of wagons for a wide range of commodities and consignments have been developed. It has also designed and developed Low Platform Container Flats, Coaching Container Flats (CCF) with a much higher payload to tare weight ratio and has designed parcel vans having a carrying capacity of 23 t.

A concentrated effort has been made by RDSO to break the speed barrier of 75 km/h of freight stock and to upgrade it to 100 km/h. The Wagon Directorate has designed and developed Bogie wagon BOXNHS, BCNAH S and BOSTHS which are suitable for 100 km/h. When more of these and other wagons suitable to run at 100 km/h are introduced on IR, it would revolutionize the freight movement as the difference in speed of passenger carrying trains and freight carrying trains would be reduced and line capacity would increase substantially with much faster freight movement.

**Coach Designs**

Indian Railways have been manufacturing the steel-bodied design of integral coaches since 1955 at ICF. This design had speed potential of 96 km/h only. The design was modified by RDSO in sixties to all coil bogies, longer suspension hangers and weight transfer through side bearers to enable speed potential to 110 km/h on main line track and gradually to 140 km/h on Rajdhani standard track.

The following main improvements in coaches for reduced maintenance, increased safety and passenger comfort have been done by the efforts of the Carriage Directorate of RDSO:-

- Stainless steel trough floor has been adopted for minimize corrosion.
- ‘K’ type and ‘L’ type composition brake blocks (including environmental friendly non-asbestos type) have been developed to improve braking characteristics and provide greater safety.
- Bogie mounted brake system has been developed and has made standard fitting on all passenger coaches currently under manufacture.
- Development of rubber springs for primary suspension has been taken up to eliminate problems of dash pot oil leakage and to improve reliability of primary suspension.
• Modular toilets have been developed in order to provide a clean and hygienic lavatory to passengers.
• Consequent upon introduction of imported LHB AC chair cars and AC generator vans, RDSO designed and developed various types of AC and non-AC LHB variant coaches based on LHB technology provided by M/s ALSTOM-LHB, Germany.

Psycho-Technical

Main objective of the Psycho-Technical Directorate is to increase job performance, job satisfaction and motivation of employees as well as prevention of accidents due to human lapses. In this perspective, directorate is engaged in research studies on variables considered important for traffic safety so that phenomena of accidents causation could be understood. On the basis of information obtained through research studies programmes, which aim to reduce accidents induced by human factors, are developed and executed. The initiation of computerised aptitude test and modular workshops on stress management for Railway officers are another landmarks of the directorate.

Increase in axle loads of freight wagons

Railway Board vide its letter No. 2005/CE-II/TS/7 Pt dated 9.5.06 (Annexure-III) approved running of CC+8+2 t loaded BOXN wagons for iron/other ores on identified routes and CC+6+2 t loaded BOX, BOBR and BOBRN wagons for identified routes for carrying coal of ‘E’, ‘F’ and inferior grade. The Railway Board has approved running of trains with such overloading subject to certain conditions essentially ensuring improved maintenance and inspection of bridges, track and rolling stock. The details have been specified in the annexure to the letter. It has also ordered that Wheel Impact Load Detectors (WILD) equipment should be installed within three months of developing vendor for supply. These orders imply that 18% more load over the carrying capacity of the wagons in case of iron/other ores and 15% more load over carrying capacity in case of coal has been allowed. These orders which were issued by the Board and have been implemented with the backing of RDSO, has allowed IR to carry substantially more freight with the existing fleet of wagons without any increase in number of freight trains. This has substantially improved the revenue earnings of IR to a record level with large profits. This increase in payload up to 18% in case of iron and other ores and up to 15% in case of coal over the carrying capacity of BOXN wagons has been permitted for identified routes which have been carrying bulk of iron ore and coal. This has been possible due to improved reliability and better maintenance practices adopted due to technological inputs provided by RDSO.

Honourable Minister for Railways Sri Lalu Prasad has appreciated the contribution of RDSO and has given the following group awards in 2006-
• Group Cash Award of Rupees five lacs for excellent work done in enhancing the carrying capacity of BOXN wagons to CC+8+2 t on identified iron ore routes to officers and staff of Track and B&S Directorates;
• Group cash award of Rupees five lacs for improved productivity of freight stock by increase in pay load during 2005-06 to the Mechanical Departments (Directorates) of RDSO;
• Group cash award of Rupees three lacs to Sr ED (M P) and his team of officers and staff in
appreciation of the good work done by them in helping to increase the movement of freight traffic.

To sum up, increased traffic has been carried by IR due to R&D inputs provided by RDSO to infrastructure and rolling stock. The old bridges have been made safe for higher loads and speeds based on field trials, study and research. Track has been modernized and its monitoring and maintenance are being done by machines. Weak formations have been strengthened as necessitated by traffic needs. Signalling and telecommunications systems have been modernized with state of art technology and several new technical innovations done by RDSO. More reliable and more fuel efficient diesel electric locos of higher horse power up to 4000 hp and electric locos with state of art technology and sophisticated control systems up to 6000 hp capable of running up to 200 km/ h have been designed and developed. These enable to carry longer trains with trailing loads of about 5000 t against a maximum of 2000 t earlier in fifties. Vacuum brakes have been replaced by air brakes to control braking distances. New designs of wagons (BOXN and its variants) with higher payload to tare load ratio have been developed and used on IR. With improved designs and maintenance standards of rolling stock and track, the reliability of train running has improved considerably. With increased traction power and braking force, it has been possible to reduce the wagon-turn-round substantially. These have enabled to carry increasing traffic by IR resulting in to better operating ratio and reduced unit cost of transportation.

The passenger movement has been faster along with the introduction of first Rajdhani Express between New Delhi and Howrah on 1st March 1969 at 120 km/ h and subsequent introduction of a number of new high speed Rajdhani, Shatabdi and Garib Rath trains. Shatabdi Express between New Delhi and Agra has been running at a speed of 150 km/ h. RDSO has developed technology and stock suitable for speeds up to 160 km/ h. The new coaches including various designs of AC coaches have the latest state of art technology with better suspension system giving more comfortable riding. The seating arrangements and interior designs of the coaches have been substantially improved with more carrying capacity. The train running has become more safe due to various safety measures adopted on IR including hot box detector, axle counter and psycho-technical inputs.

The IR has seen a momentous thrust and has become self-sufficient in all aspects of designs, manufacture of permanent way equipment, bridges, signal & telecommunication equipments, electric traction, locomotive, carriage & wagons because of sustained quality inputs through R&D support provided by this think-tank of the Railways – RDSO.

The path to progress has seen many milestones. The concerted efforts made by various directorates of RDSO have, in unison made collective input on the efficiency and efficacy of the Railway system. In the subsequent section of the book one may have a glimpse of the notable works and achievements of particular areas – Bridges, Track, Formation, Signal & Telecommunication, Locomotives, Wagons, Coaches, Traffic, M&C and others. The journey continues.....
Crashworthy Design of Coaches

There have been considerable changes, from the days of wooden body coaches to steel body coaches, in the design, materials used and manufacturing techniques employed. Wooden body coaches were not designed to resist impacts and in case of collision accidents used to disintegrate after penetrating each other. As a consequence there was heavy loss of lives and property whenever collision of trains took place. The wooden body coaches were replaced with the steel body integral design coaches.

The integral design steel body coaches have been designed to withstand static loads as per international standards. The design ensures that during normal train operations the coach is able to withstand buffing loads without causing permanent deformation. While accepting the Schillerian design of integral steel coach a collision test was conducted in Switzerland with the help of Swiss Railways. It was determined from this test that when an empty coach running at 19 km/h collides with another stationary coach then an end load of approximately 203 t is produced. The integral design of coach was developed to withstand this end load of 203 t. Design of these coaches enables them to withstand impact loads to a certain extent. However, high speed collision of these coaches may result in heavy casualties.

In view of serious collision cases and resultant casualties on IR the efforts to develop crashworthy vehicles started in right earnest. Study of several past railway accidents has shown that a majority of injuries and casualties take place in Railway coaches due to crushing of passenger area and due to climbing of coaches over one-another. Normally collision of a passenger train with another train results into heavy casualties due to limitations of design of existing coaches. The limitations are

- Deformation due to impact is not restricted to coach end, resulting in injury to passengers.
- High deceleration resulting into secondary impact (passenger impacting with coach components) causing injuries.
- Compartment deformation is such that the space between roof and underframe reduces and passengers get injured.
- Coaches climb over one another thus damaging coaches and causing passenger injury.

![Picture 1: Coaches involved in collisions](image-url)
After Firozabad accident in 1996 a limited computer model of an Integral coach was developed and it was provided impact energy similar to the accident. The computer analysis showed that the passenger area beyond the coach door absorbs a large amount of energy due to heavy deformation whereas the head stock area at the coach end had little deformation and absorbed much less energy.

To overcome the problem of heavy casualties, IR embarked on a project to develop a crashworthy coach design with a view that minimum deformation of passenger areas takes place. It was decided to work on this project in consultation with RITES and Transportation Technology Center Incorporated (USA). The objective of crashworthy design is to ensure that there is:

- No deformation in passenger occupied area;
- Energy absorption in non-passenger areas through controlled collapse;
- Low decelerations to avoid injury to passengers;
- No climbing of coaches one over the other.

The work on crashworthiness, in association with M/s RITES and M/s TTCI was started in August 2003.

As a first step a computer model of the existing design of General Second Class coach was developed. This computer model was made to impact with a rigid wall at a speed of 30 km/h (Impact of a coach with a rigid wall at 30 km/h is equivalent to 60 km/h collision between two coaches). The result of this computer simulation may be seen in picture 2. This simulation confirmed that the existing design of the coach does not have proper crashworthiness properties. The door portion of the coach deforms more than the end portion of the coach. At higher collision speeds the damage to passenger portion of the coach is more severe.

As a next step a crashworthy design for General Second Class coach was developed incorporating following:

- Shear back arrangement for the coupler;
- Honey comb energy absorber behind Center buffer coupler;
- Secondary energy absorber at side buffer locations;
- Buckle initiators on the longitudinal members near head stock;
- Tight lock center buffer coupler to ensure anti-climbing.

![Picture 2: Collision behaviour of existing design GS coach](image-url)
The computer model of this crashworthy design of GS coach was made and then simulated to impact with a rigid wall at 40 km/h. The simulation may be seen in picture 4. It can be seen that more damage is taking place at the coach end and there is limited structural damage at passenger door portion. Though this design improved the crashworthiness of the GS coach, there was still some damage near door.

A second design of the GS coach was developed to improve its crashworthiness and computer model based on this improved design was simulated to impact with rigid wall. The simulation result may be seen in picture 5. This design provided the requisite crashworthiness for 40 km/h collision wherein only end portion of the coach gets damaged. However at higher speed collisions the structural damage starts transferring to passenger portion.

The second crashworthy design of GS coach was further improved to evolve third design. Computer model of this third design was simulated to impact at 40, 50 and 60 km/h with rigid wall. The simulation result showed that the structural damage is confined to coach end only (Picture 6).

Along with the development of crashworthy design of coaches, RDSO took steps for transfer of technology and to develop capabilities for crashworthy designs. A high power compute server having 8 Xeon processors, working in parallel, and two design workstations with 3D modeling and crash simulation software have been installed at RDSO. Instrumentation and data acquisition system required for crashworthy tests have also been acquired. Concerned officials of RDSO have received training on computer modeling, simulation as well as data acquisition and analysis.

A rigid wall was required for collision test of the prototype crashworthy design coach. After discussions with consultants (RITES and TTCI) it was decided that a movable rigid wall will be better for conducting crashworthiness collision test than a fixed rigid wall. A design of this movable rigid wall was developed. A BOXN wagon was accordingly modified by
reinforcing with RCC and then making a RCC wall with a thick steel plate at one end of this reinforced wagon. This movable rigid impact wall (platen wagon) may be seen in picture 8.

A General Second Class (GS) coach was built by Rail Coach Factory, Kapurthala according to the crashworthy design. On 29th March 2005 a crash test for this crashworthy GS coach was conducted by Research Design and Standards Organization, Lucknow to see the efficacy of the crashworthy design. The coach was taken to the top of a 9 meter high ramp and then allowed to roll down and made to impact with the platen wagon. The impact speed was measured and found to be 42 km/h. This impact was equivalent to about 63 km/h collision between two coaches. After the crash test it was seen that there was no deformation in the passenger area and the damage to coach was limited to its end only. The result of the crash test was found to be in conformance with the designed behavior of the crashworthy coach.

With the successful conduct of crash test on 29th March 2005, it was decided to manufacture a rake consisting of crashworthy coaches for regular services. A rake consisting of 29 crashworthy coaches was manufactured at Rail coach Factory, Kapurthala and these coaches are running in regular train services between Barauni and Amritsar since February 2006.
The design of crashworthy GS coach was fine-tuned, to overcome few deficiencies noticed during crash test conducted on 29th March 2005, and another prototype GS coach manufactured at RCF, Kapurthala. On 17th February 2006, this GS coach was made to impact with the platen wagon at a speed of 55 km/h (equivalent to about 83 km/h collision between two coaches). This test demonstrated that the crashworthy GS coach design is able to meet the objectives of crashworthiness at higher speed collisions. It also confirmed that the few deficiencies noticed during first crash test have been overcome by suitable modifications in the design.

After successful conduct of this test the crashworthy design of the GS coach has been finalized and advised to Railway Board and production units for series manufacture. The same design was also found to be suitable for all other type of AC and Non-AC coaches except SLR and therefore adopted for them. Railway Board and Production units have been advised accordingly.

When a train collision takes place, generally SLR (Luggage cum passenger Van) is the first affected coach of passenger train. Hence crash energy absorption requirement for SLR coach is much more severe, about double, than the GS or other coaches. Therefore crashworthy design of SLR is more complicated. After gaining confidence through development of crashworthy GS coach, crashworthy design of SLR coach was evolved and prototype coach manufactured at RCF, Kapurthala. This coach along with
a crashworthy GS coach was subjected to collision test with platen wagon on 21st February, 2006 at Alamnagar Station. The objective of the test was to see the efficacy of crashworthy design of the SLR coach as well as the behavior of the interface between crashworthy SLR and GS coaches. The actual collision speed was 66 km/h (equivalent to about 99 km/h collision between two coaches) against the design speed of 60 km/h.

Since conduct of actual collision test is a costly and time consuming process it was decided that first the computer model will be made to replicate the prototype SLR coach and then it will be simulated at 67 km/h to see whether the simulation results match with the actual test results. On doing this it was found that the computer simulation matched actual test. A series of design modifications were made to the SLR to account for the lessons learned from Test 3 and the post-test analyses and optimized crashworthy design of SLR was evolved. Computer model of this design when simulated even at higher collision speeds performed satisfactorily.

The crashworthy design of SLR coach has been finalized and advised to Railway Board and Production units for series manufacture in the month of December 2006.

The work of development of crashworthy designs of GS and SLR has been accomplished in association with M/s RITES and M/s TTCI, USA. However, with the experience gained in the process, RDSO is now confident to evolve crashworthy design for LHB type of coaches, EMUs and DEMUs etc. on its own. The work of crashworthiness of LHB design of coaches has been taken on hand and it is expected that first crashworthy design of LHB coach will be developed by July 2007.

Third crashworthy test showed that the design of crashworthy SLR needed improvement. On detailed analysis it was found that there were differences in the design and manufacture of the crashworthy SLR especially in the luggage door portion. The initial crush behaviour of SLR coach was exactly as per the design and the final collapse, though not ideal, was limited to non-passenger area. The behaviour of the SLR-GS interface was as per the predictions; also both the coaches remained on track after the collision. The test confirmed that with the crashworthy design coaches there is no tendency of the coupled coach to climb over.

Third crashworthy test showed that the design of crashworthy SLR needed improvement. On detailed analysis it was found that there were differences in the design and manufacture of the crashworthy SLR especially in the luggage door portion. Since conduct of actual collision test is a costly and time consuming process it was decided that first the computer model will be made to replicate the prototype SLR coach and then it will be simulated at 67 km/h to see whether the simulation results match with the actual test results. On doing this it was found that the computer simulation matched actual test. A series of design modifications were made to the SLR to account for the lessons learned from Test 3 and the post-test analyses and optimized crashworthy design of SLR was evolved. Computer model of this design when simulated even at higher collision speeds performed satisfactorily.

The crashworthy design of SLR coach has been finalized and advised to Railway Board and Production units for series manufacture in the month of December 2006.

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Hon'ble Minister for Railways, Sri Lalu Prasad had announced the introduction of Garib Rath trains providing cheap AC travel during his Budget Speech for the year 2006-07 in the Parliament.

In pursuance of the desire of Honorable Minister for Railways, it was decided by the Railway Board to introduce fully air conditioned Garib Rath Trains with coaches having enhanced capacity with reduced fare to that of the corresponding AC 3-tier and AC Chair Car fares by about 25%. RDSO developed the coach design of Garib Rath trains with increased seat/berth capacity as compared to conventional Chair Car AC coaches and 3-Tier AC coaches. Garib Rath AC Second Class day coach has seating capacity for 102 passengers as against 78 passengers in conventional coaches. The 3-Tier AC sleeper coach has a berthing capacity for 75 passengers as against 64 berths in conventional coaches. An AC compartment for disabled passengers has also been designed.

The AC sleeper coaches have increased passenger capacity of 75, for which extra one and a half bays in the transverse side have been added while keeping the longitudinal side as earlier. This required staggering of the windows on the two side walls.

The day coach has been developed with a seating capacity of 102 passengers. The power car has been developed with the provision of AC sleeping accommodation for the wheel chair borne passengers satisfying their long pending demand. While the day coaches were manufactured by ICF, the power car and the AC sleeper coaches were manufactured by RCF.

The above coaches were developed with the existing profile of coaches. Railway Board subsequently desired to further increase the carrying capacity of AC 3-Tier coaches by introducing the 3rd Tier of Berths on the longitudinal side also. This was possible with a more liberal coach profile only. For this purpose, considering the clearances available in the schedule of dimensions, and maximum moving dimensions, Railway Board permitted that coach height can go up to 4386 mm at the center of the track compared to the existing 4265 mm i.e. an increase by 121 mm. With this permitted increase in height, a layout of AC Sleeper coach with 81 berths with a height of 4381 mm at center and side height of 3691.5 mm has been developed and is being used for the Garib Rath trains. These relaxed schedule of moving dimensions have been approved for the following four routes:-

- Nizamuddin – Patna via Kanpur, Allahabad, Mugalsarai
- Nizamuddin – Bandra via Kota, Ratlam, Vadodara, Surat
- Nizamuddin – Chennai via Agra Cantt., Jhansi, Bhopal, Nagpur, Balharshah, Vijaywada, Gudur.
- Saharsa – Amritsar via Sewan, Gorakhpur, Bareilly, Roorkee, Ambala Cantt. Jalandhar.

A prototype shell has been manufactured by Rail Coach Factory, Kapurthala and is presently under going oscillation trials after which trains with 81 berths would be introduced for commercial use.

The first Garib Rath rake was made with 12 AC Sleeper Coaches, 4 AC Day Coaches and Power Cars with an AC compartment designed for wheel chair borne passengers.

Four fully air conditioned Garib Rath trains have been introduced so far, first one between Saharsa and Amritsar, second between Delhi and Patna, third between Delhi and Chennai, and the fourth between Nizamuddin and Mumbai. Due to less fare for fully air-conditioned accommodation, these trains are very popular. Sri Lalu Prasad, Honorable Minister for Railways during the budget speed on 26th February 2007 has announced eight more Garib Rath trains to be introduced during 2007-08 between various destinations.
RDSO Today

Introduction

RDSO has been growing from early years steered by its institutional mechanisms of Central Board of Railway Research, Governing Council and Standards Committees during the past 50 years of its existence. The 100 year old speed barrier of 60 miles/hour (96 km/h) was broken in 1969 by introduction of first Rajdhani at 120 km/h between New and Delhi and Howrah. Subsequently high speed Shatabdi trains was introduced in 1988 between New Delhi and Jhansi. Garib Rath has been introduced in 2006 for the benefit of passengers who can’t afford to pay the fare of Rajdhani or Shatabdi but can now avail facilities of fully air-conditioned train at much lower fares. Now a number of fully air conditioned Rajdhani, Shatabdi and Garib Rath trains are running at speeds of 120 to 150 km/h. The Shatabdi train between New Delhi and Agra has been running at 150 km/h.

RDSO has been powering the growth of IR since its inception during the past 50 years by providing technical inputs through its research, designs and standardisation. The freight carried has increased tenfold. The safety parameters have improved. The IR has seen a momentous thrust and has become self sufficient in all aspects of designs, manufacture of Permanent Way equipment, Bridges, Signal & Telecommunication equipments, Electrical Traction, Locomotives, Carriages & Wagons because of sustained quality inputs through R&D support provided by RDSO.

RDSO is now fully geared with its team of officers and staff equipped with a number of labs furnished with latest equipments and mobile testing units. All the directorates have latest computer facilities with relevant design softwares. Tie-ups have been done for taking-up R&D with the assistance of established institutes such as IITs. For individual R&D projects tie-ups are being done with national and international R&D organizations such as UIC, Paris and TTCI, Pueblo, USA etc.

The status of RDSO has been changed from an ‘Attached Office’ of Railway Board to ‘Zonal Railway’ with effect from 1st January 2003. It has the following main functions:

- Development of new and improved designs;
- Development, adoption, absorption of new technology for use on IR;
- Development of standards for materials and products specially needed by IR;
- Technical investigation, statutory clearances, testing and providing consultancy services;
- Inspection of critical and safety items of rolling stock, locos, signalling & telecommunication equipment and track components.

RDSO also offers international consultancy services in matters pertaining to design, testing and inspection of Railway equipments as well as survey for construction of new lines. The significant accomplishments of RDSO in the sphere of research and development have always attracted worldwide attention.
**Organisation**

At the head of the organisation is the Director General ex-officio General Manager who is assisted by an Additional Director General, Sr. Executive Directors and Executive Directors, incharge for the following directorates:-
- Bridges & Structures;
- Track Design;
- Track Machines and Monitoring;
- Geotechnical Engineering;
- Signal;
- Telecommunications;
- Motive Power;
- Engine Development;
- Carriage;
- Wagon;
- Testing;
- Traction Installation;
- Electric Loco;
- Power Supply & EMU;
- Metallurgy & Chemical;
- Quality Assurance;
- Psycho-technical;
- Research;
- Traffic;
- Computer Wing;
- Defence Research

All the directorates of RDSO except Defence Research are located at Lucknow. The cells for Railway Production Units and industries which look after liaison, inspection and development work are located at Bangalore, Bhopal, Mumbai, Burnpur, Kolkata and New Delhi. Indian Railways Centre for Advanced Maintenance Technology (CAMTECH) at Gwalior is also functioning under the administrative control of Director General, RDSO.

**Support system**

RDSO has well established system to provide support to the research, designs, standardisation and quality assurance team along with infrastructure facilities including procurement of laboratory and field equipment and testing stock under administrative control of Additional Director General supported by the following sections:-
- Administrative Section headed by Executive Director (Administration) looks after the general administration, Central Library and publications of RDSO;
- Personnel Section headed by Chief Personnel Officer;
- Vigilance Cell headed by Director (Vigilance);
- Civil Construction and Maintenance Wing headed by Director (Civil) and looks after all construction and maintenance works of RDSO;
- Stores Directorate headed by Executive Director (Stores) looks after all stores requirements of RDSO;
- Thirty bedded hospital under Chief Medical Superintendent, RDSO;
- Railway Protection Force (RPF) Wing headed by Assistant Commandant.

In addition to above, Finance and Accounts Directorate headed by Executive Director (Finance) takes care of all financial and accounts functions of RDSO.

**Work force**

The RDSO has 330 officers (Group A & B) and 2509 staff (Group C & D) that is a total of 2839 in 2006.

**Expenditure**

The expenditure has been rising and was Rs. 74.45 crores in the year 2005-06.

**ISO : 9001-2000 Certified**

Seeking to nurture a quest for excellence in the sphere of research, design
and development, RDSO has today become one of the distinguished institutions of IR. Marching ahead on its way to success, RDSO has acquired the coveted ISO:9001-2000 certification in July 1999 for ‘Developing suitable designs for Railway Equipments, Sub-systems, Maintenance and Inspection’.

**Quality Policy**

The Quality Policy and Objectives of RDSO truly cherish and reflect the organization’s commitment for genuine intellectual and professional pursuit and growth.

“To develop safe, modern and cost effective Railway technology complying with Statutory and Regulatory requirements, through excellence in Research, Designs and Standards and Continual improvements in Quality Management System to cater to growing demand of passenger and freight traffic on the Railways.”

**Infrastructure**

RDSO carries out its activities through a sprawling campus spread over 159 hectares which houses amongst other things a number of laboratories well equipped with research and testing facilities for development, testing and design evaluation of various railway related equipments and materials. The main buildings are Anusandhan Bhawan (Administrative Building), Manak Bhawan (Annexe-I) and Abhikalp Bhawan (Annexe-II) which house most of the directorates of the RDSO and some of the labs.

There are number of other buildings and labs. A plan showing service buildings and residential area of the RDSO campus is placed at the end of the book. The campus has over 2000 residences which are adequate for officers and staff of RDSO.

Central Library and Publications: The Central Library of RDSO is a valuable source of information and knowledge for every inquisitive personnel. The library has more than 1.70 lacs volumes comprising books, reports, specifications and translations on Science, Engineering, Technology, Management and Railways etc. Around 160 technical journals and magazines both Indian and foreign are regularly subscribed by the library. In order to keep the research personnel abreast of the latest developments, monthly publication ‘Current Titles’ covering selected articles from various journals relevant to our activities and ‘Current acquisitions to RDSO Library’ and ‘Quarterly notification’ for IRS...
Manak Bhawan (Annexe-I)

Abhikalp Bhawan (Annexe-II)
specifications and drawings issued, modified and “IS Specifications adopted for use on the Indian Railways” were issued regularly. Membership of 10 national and international societies and institutions was taken up in order to have regular interaction with other professional bodies related with railway technology etc. The automation of library operations and services is in progress.

All the major information and result of RDSO activities were widely circulated through various research reports, codes, manuals and specifications etc. Besides, RDSO brings out quarterly magazine “Indian Railway Technical Bulletin” containing technical articles on topics of railway interest. Technical papers, technical monographs are also published by RDSO. The quarterly housejournal “RDSO Highlights”, covering prominent activities of the organisation is also published.

**Testing Laboratories**

RDSO has a number of laboratories, which are well equipped with research, and testing facilities for development, testing and design evaluation of various railways related equipment and materials as under:-

- **Air Brake Laboratory** is equipped with facilities for simulating operation of air brakes of freight trains up to 92 wagons, locos and passenger trains up to 30 coaches with twin pipe brake system.
- **Brake Dynamometer Laboratory** has facilities to develop and test brake friction materials for locos, coaches and wagons.
- **B&S Laboratory** has a 6 m x 14 m heavy duty testing floor with reaction frames for testing of full scale models of beams, slabs, columns, towers, shells and other concrete and steel components under static and dynamic loads.
- **Diesel Engine Development Laboratory** has four test beds capable of testing diesel engines from 400 to 6000 kW with fully computerised systems to control and acquire real time online measurement system consisting of approximately 200 analogue as well as digital channels and 1200 calculated parameters with programmable scanning rate for measuring different test parameters at a time.
- **Fatigue Testing Laboratory** for testing prototype loco and rolling stock bogies, springs and other railway equipments subjected to stress and fatigue so as to ascertain their expected service life.
- **Geo-technical Engineering Laboratory** is equipped with facilities for determining strength parameters of soil in lab and field condition. The state-of-the-art Sub-surface Interface Radar (SIR) system, Laser based soil particle analyzer and computerised consolidation test apparatus have been installed in the lab.
- **Metallurgical & Chemical Laboratory** is capable of destructive and non-
destructive testing of metals, polymers, composites, petroleum products and paints.

- **Psycho-Technical and Ergonomics Laboratory** facilitates the assessment of critical psycho-physical attributes of operational staff such as drivers, switchmen and station masters for efficient operation. The ergonomic laboratory is also equipped with bio-feedback system for assessment of Electro Mayo Graph, GSR (Galvanic Skin Resistance) temperature, pulse and respiration rate and is used for stress management exercises.

- **Signal Testing Laboratory** is capable of testing of all types of signalling equipments such as safety signalling relays, block instruments, power supply equipments, point machines, signalling cables, electro-mechanical signalling equipments/ components, triple pole double filament lamps, power supply equipment etc.

- **Telecom Laboratory** is equipped with latest electronic testing and measuring equipments and is capable of testing of all types of telecom equipments.

- **Track Laboratory** for testing full scale track panels under realistic dynamic load patterns and fatigue testing of welded rail joints.

- **Traction Installation Laboratory** is equipped with Universal Tensile Testing Machine, FUT 20, for testing Tensile Strength of Insulators. It is also equipped with Hardness Testers NB – 250 & NB – 3000 for testing hardness of metals.

- **Vehicle Characterisation Laboratory** for conducting vehicle characterisation tests on Railway vehicles to study the behaviour of suspension systems and to determine natural frequencies. It also has an impact ramp from where vehicles are rolled down at different speeds for conducting the crash test.

- **Mobile Test Facilities** for recording of track parameters, loco power and conducting oscillograph trials for evaluating vehicle-track interaction and also for monitoring track conditions:-

- **Oscillograph Car** for recording track and vehicle parameters and track and vehicle interaction studies;

- **Brake Dynamometer Car** for measurement of braking effort and coupler forces;

- **NETRA Car** for testing and recording parameters of over head traction equipments is available which records 5,000 to 10,000 km per year and is useful for directed maintenance.

**Participation in UIC-Paris projects:**  
RDSO is participating in Joint Research Projects (JRP) of UIC:-

- **UIC Project on Rail Defect Management (JRP-I):** In a joint project with UIC, RDSO has taken-up a project to improve rail defect inspection and rail failure prediction technologies. RDSO was entrusted with the task of laboratory testing of rail samples from various world railways under simulated loading conditions. Special set up was created in Track Laboratory of RDSO for simulating the loading conditions and 19 samples from Japan (8 nos.), India (4 nos.), America (3 nos.) and South Africa (4 nos.) have been tested.

- **UIC Project on Rail Wheel Interaction (JRP-2):** RDSO has been assigned the work of ‘Defining/ describing/ cataloguing the Rail-Wheel interaction phenomenon and mechanisms with respect to vertical and lateral discontinuities’ at rail/ welded joints.

- **UIC Project on Automated Health Condition Monitoring & Predictive Rolling Stock Maintenance (JRP3):** To induct new technology for automatic monitoring of the condition of rolling stock, IR through RDSO is participating in UIC joint research project.
Collaboration with Research and Academic Institutions

RDSO recognised the imperative need to generate basic knowledge through advanced academic research to enable a truly self-reliant Railway Technology Improvement Programme for the country in the coming years.

- **Collaboration with IIT, Kanpur**: A ‘Railway technology cell’ has been set up jointly by RDSO and IIT, Kanpur. A sum of Rs One crore has been paid as Endowment towards the setting up of this cell for research in the fields of Geo-technical engineering and Mechanical engineering. Projects are funded by the interest accrued annually on this amount. The following projects are in hand under the aegis of this ‘Railway technology cell’:-

  - **Projects under Rail Technology Cell**:
    
    i. **Development of indigenous Wheel impact load detector**: The technology has been successfully demonstrated in the Lab and field trials for validation of the equipment are complete and equipment can now be used in field conditions. Also a miniature version based on embedded technology is being developed further.

    ii. **Field validation of design methodology of Railway Formation** for rehabilitation of unstable formation and strengthening of existing formation for heavier axle load;

    iii. **Development of methodology for investigation of unstable formation and its rehabilitation with SASW techniques**: This is aimed at examining the engineering properties of existing formations for optimizing the thickness of blanket to provide stable formation.

  - **Other projects with IIT, Kanpur**

    i. **Rail Fracture Detection System**: The project is aimed to develop a system to detect rail fractures, which will eventually enhance safety of track.

    ii. **Seismic Isolation and Protection System and development of guidelines/ Codes for Earthquakes and Laboratory Facilities for testing of bridges**: The objective is to make seismic designs and give guidelines to retrofit damaged bridges in economical and safe manner.

- **Collaboration with IIT, Delhi**:

  - Numerical modelling of railway tracks on compacted sub-grades for design of track formation on soft soil, accurate prediction of stresses, decision making for track maintenance etc.

- **Collaboration with IIT, Kharagpur**:

  - Continuous bridge pier/abutment foundation, Scour Monitoring using Time Domain Reflectometry etc to develop a rational approach for scour estimation in bridge design for new railway bridges and also as regular means of scour measurement during floods on important bridges.

- **Collaboration with IIT, Mumbai**:

  - Vibration signature analysis, vibration test condition assessment of bridges and development of instrumented rail vehicle testing car for bridge health to monitoring the condition of bridges in a faster manner, under dynamic conditions, without interruption to traffic and for giving overall condition assessment of the structure.

    - Pilot study for technical suitability of coal ash in railway embankment for conservation of top fertile soil and use of industrial waste;

    - Remote monitoring of bridges and
monitoring of bridges using optical fibre technology to develop a better health monitoring system for the bridges.

Collaboration with IIT, Roorkee

Two professional chairs have been set up at IIT, Roorkee by payment of endowment money by IR and using its annually accrued interest for R&D work. These chairs deal with Bridge Engineering and Dynamics of Rail Vehicle System.

- **Chair on Bridge Engineering:** It is dealing with a project for revision of fatigue provisions in IRS Steel Bridge Code so as to optimize the design of steel bridges.
- **Chair on Dynamics of Rail Vehicle System:** A project on study of aerodynamic behaviour of passenger trains and development of aerodynamic profiles of coaches and locos to reduce wind resistance is being processed.

Other Projects with IIT, Roorkee:

- Provision of LWR on Railway Bridges for making rail structure anti-miscreant and for smooth running;
- Vibration signature analysis, vibration test condition assessment of bridges and development of instrumented rail vehicle testing car for bridge health to monitor the condition of bridges in a faster manner, under dynamic conditions, without interruption to traffic and for giving overall condition assessment of the structure.
- **Cooperation with the Defence Research & Development Organization (DRDO):** RDSO is actively involved in the design of new stock as required by the Defence forces for movement of men and material. This work is carried out by RDSO jointly with the DRDO. In addition, DRDO and RDSO are working together for development of environment friendly toilet discharge system in coaches for IR.

- **International Cooperation:**
  - RDSO is participating in the SELCAT project of European Commission for improving safety at level crossings. This is being coordinated by Technical University Baunschweing of Germany.
  - RDSO is participating in the Global View Project of European Commission which is being coordinated by UIC for strengthening rail research cooperation between Europe and emerging regions namely China, India and Russia.
  - RDSO is also represented in the International Rail Research Board meetings of UIC. Last meeting was held in Paris on 5th and 6th December 2006 to present current research efforts on customer satisfaction and environment/energy.

Recent Achievements:

- **Garib Rath:** Hon’ble Minister for Railways, Sri Lalu Prasad announced the introduction of Garib Rath trains for providing cheap AC travel during the budget speech for the year 2006-07. In pursuance of the desire of the Honorable Minister for Railways, Garib Rath trains have been designed by the RDSO and prototype rakes have been constructed in RCF, Kapurthala. Four Garib Rath trains have already been introduced on IR. The fares are substantially less than the conventional AC fares for Chair Cars and AC 3-Tiers and are very popular.

- **Development of hotel load locos:** Power required for lighting fans and air conditioning of a coaching train is referred to as hotel load. On Mail/Express trains hotel load requirements are met through self-generating equipment. This system has around 50% efficiency only leading to enormous wastage of energy. On Rajdhani/ Shatabdi trains, hotel load requirements are met through two power cars provided on each end of the train. Though the system is
energy efficient, provision of two power cars is a waste of commercial space that could have otherwise been exploited. Therefore, it is planned to develop loco with hotel load capability. RDSO has developed design for 3300 hp diesel loco with hotel load capability and sent the specifications and equipment schedule to DLW, Varanasi. Railway Board has given approval for developing two such locos on trial basis. Hotel load will be met from a companion alternator through rectifier, invertors and transformer. The equipment has been type tested and dispatched to DLW. Two prototype locos are currently under manufacture at DLW.

Another project was taken up by RDSO to provide hotel load on 4000 hp GM loco (WDP4) by providing addition IGBT converter of 500 KVA. Design has been evolved and specification was issued to DLW. Railway Board have cleared development of 10 such locos at DLW. Electrics for these locos are under procurement. Hotel load on locos will lead to efficient power management on coaching trains and will result in large energy savings.

- **Operation of Double Stacked Container service:** Containerisation is one of the important innovations in logistics that revolutionized freight handling in 20th century. It has significantly reduced freight charges, in turn, boosting trade flows. In order to reduce transportation cost of containers by Rail, double stacking of containers was initiated in 1984 by U.S. Railroads using “well” wagon design. Soon, this became very popular among shippers and now accounts for more than 70% of intermodal rail freight transport in U.S.A.

  On 24th March 2006, IR joined the select club of double stacked container train operation by running its first train from Jaipur to Pipavav Port. RDSO conducted feasibility study, computer simulation study, assessed safety requirements, conducted oscillation trials, issued speed certificate for running double stacked container train services by the Zonal Railway. Unique feature of IR operation is carrying double stacked containers on flat wagons, which increases throughput per rake by 100% as against 40% increase in throughput for well wagon design as is the practice on US Rail Roads. This has been possible by exploiting the wider track gauge of 1676 mm on IR compared to 1435 mm for US Railroads. Double stack container operation will cut down the cost of rail transportation per unit to half contributing to competitiveness of our exports as well as increase market share of Indian Railways in container movement viz a viz road sector.

  The operation has been started with an axle load of 20.32 t and efforts are being done by RDSO to increase the axle load to 22.9 t so that most of the containers can be carried in combination, cutting down time wasted in selectivity of containers at terminals.

- **Crashworthy design of coaches:** Crashworthy design of coaches is of vital importance for safety of passengers in case of accidents. The crashworthy design of coaches of GS and SLR and other variants of ICF coaches based on the crash test done by the RDSO in February 2006 has been finalised. The Production Units have been advised of the design for series manufacture. A project for development of crashworthy design of LHB/Alsthom has been taken up.

- **Fire worthy coach:** Fire accidents cause sometimes huge loss of human life and property. A project is in hand to improve
the design of the coaches so as to reduce damage due to fire. The specification of fire retardant rexin has been issued. Fire retardant PU foam, Vestibule and FRP windows are being developed.

- **Heavy axle load**: Increasing freight requires increase in the trailing load with more payload to tare weight ratio and higher axle load. Encouraged by introduction of BOXN wagons over several important routes with CC+8+2 t, RDSO is moving in a direction towards universalizing 23 t axle load. CC is the design carrying capacity of the wagon and (8+2) or 10 t is the overload allowed on specified routes for iron ore etc. The design of the 22.9 t covered wagon has been conceptualized. This will be for the length of BOXN wagon having width of 3500 mm equal to that of BOBRN wagon with height as per relaxed maximum moving dimensions for Garib Rath train. This will increase the volume per rake by 21% as compared to existing BCNA wagon. There will be an increased throughput of 36% for cement, 32% for food grains and 21.5% for fertilizer as compared to throughput of BCNA rake with permitted overload. 25 t axle load iron ore wagon (BOY 25 t) has been designed which will increase throughput of iron ore by 24% compared to existing BOY wagon with 22.9 t axle load. Conceptual design of 25 t axle load BOXN wagon has been made which will increase throughput by 14.5% over the rake of conventional BOXN wagons with CC+8+2 t loading. These designs will enable substantial increase in throughput without posing any line capacity problems.

- **Data logger for double rail ultrasonic testing**: Ultrasonic testing of rails (USFD) is necessary to avoid accidents on account of rail or weld failures. Presently USFD is being done on IR but the data is manually handled. To improvethesystem, a prototype data logger has been developed in association with industry and trials are being conducted on Zonal Railways.

- **Zero toe load elastic fastening**: On ballasted deck bridges due to thermal expansion and under passage of the trains there is relative movement between rail and the ballast deck. In case of LWR, it is necessary to have rail free fastenings to take care of this relative movement. Therefore, zero toe load elastic fastening has been developed by the RDSO to be used on concrete sleepers on bridges. This will facilitate continuation of LWR on ballasted deck bridges where use of rail free fastening is stipulated. The design has been released for field trials.

RDSO has been powering the growth of IR since its inception during the past 50 years to carry increasing freights at higher speeds with more safety and economically by technical inputs through its research, designs and standardisation. It is now fully geared with its team of officers and staff well equipped with a number of labs furnished with latest equipments and mobile testing units. All the directorates have latest computer facilities with relevant design softwares. Tie-ups have been done for taking-up R&D with the assistance of established institutes such as IITs.

RDSO continues the journey ahead.....
India has now been developing with GDP growth of 8% to 10% per annum, which is amongst the highest growth rates in the world. Freight to be handled by IR is increasing fast due to development of the country. Within next few years the freight to be transported is expected to reach on billion tonne/annum from 726 million tonne transported in 2006-07. This is very high growth and throws a big challenge. Though safety has been improving, it has become very important due to rising expectations of the people from IR. The reliability of fixed assets viz tracks, bridges, signals and telecommunications as well as that of rolling stock including locos, wagons and coaches has become very important to ensure better quality of service for both freight and passengers. Due to fast changing technology, existing designs and specifications have to be updated and modernized at a faster pace so that full advantage of technological innovations could be taken. Latest technological developments anywhere in the world which could be of use have to be introduced on IR by technology transfer and absorption of technology followed by appropriate upgradation of the technology for the benefit of IR. Throughput and speeds have to be increased to carry more traffic with minimum expenditure. New innovations have to be done and introduced on IR for environmental considerations.

Additional facilities

- **Test Track**: A test track for speeding up various trials and studies in the field conditions is proposed to be set-up. This is being taken up in collaboration with Transportation Technology Center Inc., USA for which a Memorandum of Understanding is being drawn. This will be one of the most important test facilities for speeding up various trials and studies in field conditions. The test track will be utilised for:
  - Oscillation trials, braking and coupler trials, rating and performance trials for all type of rolling stock;
  - Accelerated fatigue testing of components for track and rolling stock;
  - Derailment studies;
  - Rail-Wheel Interaction and other research studies;
  - Training.

**High Speed SPURT Cars**

The rails are required to be inspected periodically for detection of cracks to ensure safety and to minimize disruption of traffic on account of rail and weld failures. Rail flaw detection on IR is predominantly being done using manually operated portable machines, which have limitations in terms of quality, accuracy and reliability. Therefore, high speed SPURT Cars are planned to be procured which would greatly enhance the ultrasonic rail testing capability of IR and also provide database on rail flaws for future study and analysis.

**Proposed New Works**

RDSO has proposed (Preliminary Works Programme 2007-08) to take up the following new works through Works Programme, 2007-08 estimated to cost Rs. 118 crores:

- Design and development of 25t axle load wagons for existing IR system and 32.5 t axle load for DFC with technical collaboration with TTCI, USA;
- Procurement of Emission Test car to measure exhaust emissions from diesel locos;
- Augmentation of test facilities in Air Brake Lab;
- Development of Testing Facilities for higher axle load wagons with technical collaboration with TTCI, USA;
- Setting up of Composite Development Center in RDSO to develop appropriate composite materials in critical railway components;
- Design and development and upgradation of track for heavier axle loads with technical collaboration with TTCI, USA;
- Development of Kinematic Gauge for double stack container trains operations using BLCA/B container flat wagons;
- Study to determine permissible height of Centre of gravity of wagons;
- Consultancy work for setting of fire testing facilities in RDSO;
- Consultancy work for up gradation of NG rolling stock;
- Consultancy for test track loads with technical collaboration with TTCI, USA;
- Capability assessment and condition assessment of bridge with technical collaboration with TTCI, USA;

**Areas for future R & D**

Wage bill and the cost of the fuel consume a major portion of IR revenue. These costs have increased fast. Due to rising expectations of the public and stiff competition from other modes of transport, freight tariffs and passenger fares cannot be increased. It is necessary to improve passenger comfort. Therefore, IR has to make optimum use of the assets at its command for which technical inputs have to be provided by RDSO. Lot of design modifications have to be done to reduce fuel consumption per million tonne kilometer. World is shrinking and the technological changes are taking place at a very fast pace. It is necessary to have close coordination and synergy with other national and international research organizations and also with public undertakings and industry. Keeping in view these aspects, RDSO for 11th Five Year Plan (2007-2012) has considered the following broad areas for R&D:-

1. Increased freight transport;
2. Safety;
3. Reliability of assets;
4. Upgradation and modernization;
5. Increased throughput and speeds;
6. Environment;
7. Passenger comfort;
8. Cost optimization and energy efficiency.

The broad scope of the projects for R&D is as under:

1. **Increased freight transport:**
   - **Existing network**: On the existing IR network increased freight is to be carried for which, action has been initiated to increase the carrying capacity of the existing freight trains with increased axle loads, higher loading density of wagons, higher payload to tare weight ratio along with improved braking. New types of wagons have to be designed. Bridges and tracks have to be rechecked and strengthened. Maximum moving dimensions have also to be reevaluated for relaxation to carry more freight and passenger traffic as has recently been done for Garib Rath trains where relaxation in maximum moving dimensions in case of height has been given on selected routes to increase berthing capacity in AC 3-tier coaches. These works have to be done with utmost care after thoroughly considering all aspects of safety of track and bridges.
Freight corridor: The traffic on the Golden Quadrangle connecting Delhi, Mumbai, Chennai and Kolkata has reached saturation level. More trains cannot be run on the existing track with mixed freight and passenger traffic on it. The freight trains are slow moving in comparison to passenger carrying trains. This restricts the line capacity due to mixed freight and passenger traffic. Realizing this fact, IR has decided to have dedicated freight corridors (DFC) exclusively for carrying freight on routes having very heavy freight traffic. Initially two freight corridors are being taken up one between Delhi and Mumbai and the other between Delhi and Kolkata.

Dedicated Freight Corridors one between Delhi and Mumbai and the other between Delhi and Kolkata have been taken up at a cost of Rs. 30,000 crores. Further corridors may be taken up in near future. To take full advantage, maximum moving dimensions and new schedule of dimensions have to be such that the rakes can be loaded to large trailing loads say up to 12 t/m with axle loads of the order of 30-32.5 t. The height gauge may be of the order of 7.0 meter to provide adequate volumetric capacity and also to transport containers in two and three layers. The stability due to increased height of centre of Gravity of a loaded wagon has to be considered. Its effects on train forces in track have to be evaluated. The bridges, formation and track along with yards have to be suitable for these loads. Diesel and Electric locomotives with higher horse power say 6000 hp in case of diesel loco and up to 8000 hp in case of Electric loco have to be designed with the latest state of art technology. The braking power has to be improved so that the trains could be controlled in reasonably short distances in case of emergency. Locotrol have to be developed for running heavy haul trains with multiple locos without much increase in train forces due to traction and braking. Signalling and communication systems have also to be strengthened and freshly designed for the heavy haul trains. Traction installations will also need to be redesigned and modified. New couplers have to be developed for increased train loads as a result of increased traction and braking forces. New designs of wagons have to be developed with higher payload to tare load ratio with increased axle loads and higher trailing loads per running meter. All the technical inputs have to be provided by RDSO.

MoU with Transportation Technology Center Inc., USA (TTCI): Indian Railways through RDSO is entering into a MoU with TTCI, USA for undertaking projects which will help IR to implement heavy haul operations. The following projects are planned to taken up:-

Design and Development of 25 t Axle Load Wagons for Existing IR System: The project aims to develop design capability of RDSO for 25 t load, higher pay to tare ratio, reliable wagons with state of art technology so that RDSO can provide design and develop wagons for IR to increase throughput and reduce unit cost of transportation. It will also help RDSO to codify design procedures for such wagons and evaluate designs submitted for approval by private party/ wagon builders.

Design and Development of 32.5 t Axle Load Wagons for Dedicated Freight Corridor: The project envisages development of design capability of RDSO for 32.5 t load, higher pay to tare ratio, reliable wagons with state of art technology so that RDSO can provide design and develop wagons for IR to increase throughput and reduce unit cost of transportation. This project will enable RDSO to codify design procedures for such wagons and evaluate designs submitted for
approval by private party/ wagon builders.

- **Development of Testing Facilities for Higher Axle Load Wagons**: The project will help to understand and finalize the various testing procedures as described under AAR specification Section C – Part-II, Chapter XI, suitable for IR high axle load (i.e. 25/32.5 t) wagons to ensure safety and reliability of rolling stock and to further develop the testing facilities for the same as already mentioned in the chapter.

- **Design, Development and up-gradation of Track for Heavier Axle Loads**: The track structure for dedicated freight corridor needs to be designed for operation of 32.5 t axle load. In addition, the identified feeder routes of IR network will have to be upgraded for operation of 25 t axle load. It is, therefore, essential to technically evaluate the track structure and identify required inputs for up-gradation of track at most economical cost. Also, the track structure, fastenings etc. need to be suitably designed and the likely problems in maintenance of track structure due to higher axle load operation needs to be suitably addressed.

- **Consultancy for Test Track**: The scope of the project will include:
  - Layout and design of test track including curves, gradients, loops, track lengths etc.;
  - Identification of various types of tests required to be conducted on track components, bridges, formation, rolling stock and locos including tests for derailment susceptibility and crashworthiness;
  - Developing testing methods;
  - Specifications for test equipments and design requirement for tests;
  - Requirement of hardware and software for data collection, analysis etc.;
  - Commissioning of the agreed upon test facilities in India;
  - Training of IR personnel on actual test sites in India and abroad.

- **Capability assessment and condition monitoring of bridges**: The scope of the project will include:
  - Methodology to identify bridges capable of heavy axle loads;
  - Provision of software for bridge load analysis and Bridge Management System under a license agreement;
  - Development and implementation of a condition monitoring system;
  - Review of codes and recommendations for changes with reference to bridge rating to facilitate HAL implementation;
  - Training of IR engineers in India and North America.

- **Wayside bogie performance detection system**: The system is installed along the track to monitor bogies having poor curving performance by measuring lateral and vertical forces exerted by the wheels and the angle of attack.

- **Trackside acoustic bearing detection system to monitor and detect bearing defects in IR’s Train**: The system is based on acoustics and is installed along the track to identify defective axle box bearings. Unlike infrared based systems which detect defective bearings on the verge of failure, the system will predict bearing failures in advance allowing time to replace bearings before they fail on line.

- **Schedule of Dimensions**: Schedule of Dimensions which lay down the maximum and minimum dimensions for all fixed structures and also the maximum moving dimensions of the rolling stock are vital and limit the maximum capacity of a freight wagon or a coaching stock. These are statutory requirements and also specify extra clearances on curves, OHE installations etc. Any change requires an in-depth study of its implications. It has
essentially remained unaltered except for some changes which became necessary due to electrification or for introduction of wider stock.

Now due to increase in freight and passenger traffic coupled with the necessity to optimize the resources, heavier train loads with heavier axle loads and more volumetric capacity have become necessary. Therefore higher and wider stocks are required not only for the Dedicated Freight Corridors but also on the existing routes of IR. Recently container trains with two layers of containers have been introduced needing more clearances. Some action has been taken in case of Garib Rath trains where some relaxation in height has been permitted on specified routes. RDSO is having a detailed study to review the Schedule of Dimensions with a view to relax them with minimum changes required to meet the operating needs of IR. A note prepared by the Track Directorate of RDSO on the Schedule of Dimensions giving a brief history and the present position is placed as Annexure-VII.

2. Safety

Improvement in safety is a continuous process and has to be vigorously pursued. RDSO is taking action in this regard. Important projects being taken up or in progress are as under:-

**Technological Mission for Railway Safety:** Honorable Prime Minister of India, Sri Atal Behari Vajpeyee during Independence Day speech made on 15th August, 2003 announced that:-

“A Technology Mission for Railway Safety will be set up to comprehensively address safety-related issues in Indian Railways. This will be done in collaboration with the Department of Science & Technology, IIT/ Kanpur and a consortium of private sector companies”.

Accordingly Technology Mission for Railways safety was set up. The Technology Mission for Railway Safety has been vigorously followed up and is now in an advanced stage of progress as may be seen from the write up of Research Directorate contained in Section – II of the book. RDSO has taken up several projects for improving safety under a trident consortium comprising of IIT/ Kanpur, RDSO/ Lucknow and industry. Twelve vital projects for improved railway safety have been taken up.

In addition to above, a number of other R&D inputs are being provided by RDSO for safety. Projects are already in hand for crashworthy design of coaches so that damage in case of accidents is minimised.

- Computer simulation of spread of fire in coaches is planned to be studied by RDSO. Fire testing facilities are being developed in RDSO so that better prevention of fire damage could be ensured. The design of the coaches has to be modified to control damage due to fire.
- Derailment detection devices for sensing derailment conditions and predicting derailment by lowering threshold values have to be developed. Driver’s vigilance monitoring and control system has to be developed so that there is automatic braking of the train in case the driver is not vigilant.

3. Reliability of assets

RDSO is planning to take up a number of projects to improve the reliability of assets some of which are as under:-

- On-board diagnostics system;
- Rail stress calculation and in-situ measurements;
- Improvement in elements of Casnub bogie;
- Upgradation for reliability of brake system of wagons;
- Development and introduction of composition brake blocks with inserts for wheel reconditioning and higher life;
- Upgradation of technology of coupler and draft gear for existing wagons and also acquiring the latest state-of-the-art technology for higher axle load wagons (22.9 t axle load and above);
- Development of laser based OHE recording-cum-test car for measurement of OHE parameters and geometry;
- Development of laser based measurement system for live scanning of contact wire thickness for fitment on NETRA;
- On-line monitoring of insulators;
- Condition monitoring of lightning arrestors;
- Development of IGBT based Converter;
- Development of Lab for testing of electronic components and insulating materials.

In addition to above projects, some projects have to be taken up for improving the reliability and life of materials. Advance corrosion prevention systems for bridges have to be developed and introduced. Rail weld fractures detection system has to be improved so that after ultrasonic testing a rational decision could be taken for the time in which a defective rail may be required to be replaced.

4. Upgradation and modernization

It is essential to upgrade and modernize the rail network and rolling stocks to meet the future challenges. RDSO is planning to take up a large number of projects for this purpose. Improvement in rail manufacturing along with indigenous manufacture of head hardened rails and transportation of longer rails is being planned. Improvement in design of turnouts to achieve better service life is also being taken up. Bridge scour estimation measurement and protection systems have to be improved. Accelerated bridge construction techniques to reduce construction time have to be developed and introduced. A number of projects are being planned for tackling the formation problems and improving the track reliability for higher loads.

The Traction Installation Directorate is planning a few projects to improve reliability and quality of service of OHE and its equipments. Metallurgy & Chemical Directorate is planning to take up projects for improving the quality of service and improving the materials required for IR.

RDSO is planning to develop 6000 hp diesel locos and 8000 hp electric locos with IGBT based propulsion system. Development of soft side buffers for passenger coaches so as to reduce jerks during braking are planned to be developed.

A project for value added services through global system for mobile communication for Railways (GSM-R) is proposed to be executed by RDSO. ‘End of Train Telemetry’ (EOTT) is also planned to be taken-up. Signal Directorate has proposed for development of Centralized Traffic Control/ Train Management system.

5. Throughput and speed

The main projects envisaged are:-
- Development of universal simulation software train operation as a Railway
network calculation tool;
- 5000 hp and 6000 horse power diesel electric locomotives;
- Development of high reach pantograph;
- Development of Locotrol for electric loco;
- Development of 1600 hp AC/AC DEMUs;
- Simplified version of three-phase IGBT based AC Electrics for Electrical Multiple Units (EMU) for speed potential of 160 km/h.

6. Environment

The following action is being planned for the future:

- **Reduction of Emissions from Diesel Engines:** USA has done the maximum work in the world in the field of measurements, control and legislation for the emissions from diesel locos. In Europe, although European Rail Road Institute has done the work to finalize emission testing procedures and testing cycles for emissions from diesel locos, at present there is no legislation to regulate the loco emissions. Even though there is presently no legislation in India for limiting the emissions from locos, IR has made an action plan to for measurement of emissions as per International Standards. It will be followed by their reduction to the levels specified in EPA and UIC standards. In view of above, RDSO has procured a dedicated Mass Emission Measurement System consisting of Gas Analyzer for measurement of Nox, CO, CO₂, total Hydrocarbons and Oxygen content of exhaust. It has Partial dilution tunnel for measurement of particulate matter and Smoke Meter for finding out the opacity levels of exhaust gases.
- Use of bio-diesel blends in locomotives which are more environmental friendly.
- Use of eco-friendly (HFC) refrigerant in AC coaches;
- Noise reduction in power cars;
- Removal of harmful gases from exhaust of power car.

7. Passenger comfort

Improving passenger comfort has become essential due to rising expectations of the people from IR. A number of innovative designs of coaches are being developed providing more comfort. The designs have to be improved along with better riding comfort by RDSO.

8. Cost optimization & energy efficiency

Cost optimization is very important by bringing about all round improvements through technological inputs as the cost of energy (diesel and electric) is the highest next to staff costs on IR. Therefore, R&D inputs are required for improving the designs of the locos so that they are more fuel efficient. RDSO has already initiated action in this direction. Power Upgradation of 12-Cylinder Diesel Engine and Reduction in Specific Fuel Consumption of 6-Cylinder Diesel Engine projects are being taken up by RDSO. Details may be seen in the write up of Engine Development Directorate in Section II of the book.

With a glorious past, RDSO continues the journey ahead powering the growth of IR ....
SECTION II

CONTRIBUTIONS BY DIFFERENT DIRECTORATES
Bridges and Structures Directorate

General

The B&S Directorate looks after the designs and standardisation for bridges and structures including hydro-meteorological design for bridges. The directorate is headed by Executive Director/ Director Standards (B&S) since 1986. Earlier the work of the B&S Directorate was divided between Director Standards (Civil) and Director (Research) since inception of RDSO in 1957. The standards part of the directorate looks after the work of standardisation of codes and manuals including design loads and issue of standard drawings for bridges and structures. It also prepares designs and drawings for special bridges and structures and gives advise to Zonal Railways on bridge problems. It was headed by Additional Director (B&S)/ Jt. Director (B&S) under Director Standards (Civil).

The Research Wing was carrying out investigations and testing of old bridges including arch bridges, field tests for dynamic augment on bridges due to high speeds and diesel electric locos, study the effect of dispersion of longitudinal forces (traction and braking) and testing of building materials such as coal ash for use in masonry, tensile strength of masonry and field investigations of problems referred by the Railways to RDSO. The Research Wing was initially headed by a Dy. Director but soon it was placed under JDR (B&F).

On the recommendations of Khosla Committee appointed by the Government of India to avoid recurrence of hydraulic failures of bridges due to inadequate waterway, afflux, scour etc., a post of Director (Bridges & Floods) came into operation under RDSO with headquarters at New Delhi in 1960. This post was transferred to RDSO, Lucknow, in early sixties and was carrying out hydrological studies. The post was downgraded to the post of JDR (B&F) and was placed under Director (Research). The problems to Research Wing of B&S were referred for investigations including tests and trials by the Standards Directorate. This arrangement continued till 1986. Since April 1986, the post was upgraded to the Director Standards (B&S) and Research Wing of B&S including JDR (B&F) and JDR (B&S) were brought under administrative control of Director (B&S).

This arrangement has been continuing and the Director Standards (B&S) has been renamed as Executive Director (B&S) w.e.f. August 1995. It is to be pointed out that both the posts i.e. Director Standards and Executive Director are in senior administrative grade. The nomenclature was changed as the designation of SAG officers in other Ministries and Railway Board is Executive Director and the officers in selection grade are called Directors. Thus, the renaming of Directors as Executive Directors was done to remove this anomaly in all the directorates of RDSO in 1995.

The Bridges & Floods Directorate have served the purpose for which it was created and has since been merged with B&S directorate. A separate write-up has been given for activities and achievements of B&F Directorate.

After independence and with the development of the country and industrialization, traffic was growing and need was felt to increase the speeds of the train along with increasing trailing loads with operation of coupled diesel electric...
locos. Necessity was also felt to increase the axle loads by revising the loading standards. It was an extremely difficult challenge as 70% of over 1,21,000 bridges on IR are more than 100 years old and have outlived their service life. They were designed and constructed in nineteenth century or early twentieth century when there was no provision for longitudinal forces in the design codes and the axle loads were light. There were hundred of bridges in distressed condition. Rebuilding of bridges is very costly and time consuming and requires lot of traffic blocks which affect the train running. Therefore, the first task of B&S Directorate was to study different types of bridges theoretically and also find out reserve strength by Lab and field trials along with study of the world literature. This has been done during sixties to eighties. In sixties and seventies, the impact factor was revised for diesel electric locos and higher speeds as the existing provision in IRS Bridge Rules were only for steam locos up to 100 km/h.

The BG ML loading of 1926 was revised by RBG loading in 1975 with increase in tractive force up to 75 t from earlier 47.6 t for coupled operation of diesel electric locos and was again revised by heavier MBG loading of 1987 having 25 t axle load followed by a train load of 8.25 t/m. The loading has further been increased to Heavy Mineral Loading (HM loading) with maximum axle load of 30 t and train load of 12 t/m for specified routes to be designed for this loading. These changes in loadings have required lot of investigations for bridges of different spans, designs and construction materials.

B&S Directorate has done commendable work for revising the loading standards to meet the needs of IR along with revision of various codes, manuals and specifications and has issued detailed standard designs and drawings for various loadings for different type of spans along with guidelines for strengthening. It has carried out a lot of field investigations and research and has provided consultancy to Zonal Railways on all problems connected with bridges and structures.

**Laboratory**

The directorate has a full fledged laboratory for quality control and field related testing equipment and modern equipments for Non-Destructive Testing (NDT) along with facilities for fatigue testing. NDT equipments available in the Lab consists of Compression testing machine; Rebound hammer; Ultrasonic pulse velocity meter; Profometer; Corrosion analyzer; Acoustic emission equipment; Crack detection microscope; Resistivity meter; Cover meter; Pull off tester; Windsor probe; Core cutter; Inclinometer; and Digital ultrasonic measuring tools.

**Main Activities:**

A. **Revision of loading standards:** With increase in traffic the loading standards on IR are being constantly revised. During the last 50 years the following standard loadings have been revised for BG:-

- BGML loading of 1926 was revised to RBG loading of 1975 with axle loads of 22.5 t and trailing loads of 7.67 t/m and maximum tractive force of 75 t against 47.6 t of BGML loading.
- MBG loading-1987 with axle load of locos up to 25 t and trailing load of 8.25 t/m and maximum tractive force of 100 t against 75 t of RBG loading;
- Heavy Mineral Loading with axle load of 30 t and trailing load of 12 t/m to be adopted on specified routes only;
Loading for gauge conversions of MG to BG: This loading was introduced in early nineties when a decision was taken by the Board to convert MG to BG on mass scale to have uni-gauge on IR. This loading is lighter than standard loadings with a view to retain maximum number of MG bridges on gauge conversion.

Before carrying out any revision of the standard loadings, the directorate carries out detailed analysis on all types of bridges such as open web girder bridges, PSC bridges, plate girder bridges, arches, pipes, box culverts etc. and for all spans. The extent of workload for rebuilding/strengthening measures on various types of bridges getting affected by increased loads for permitting the desired loading is worked out after considering the various strengthening measures on various routes. The loading can only be permitted if each and every bridge is safe for the loading on the section/sections where the desired loading is to be introduced. Even a single bridge failure can be catastrophic. Therefore, a very thorough analysis is required to be done. All the standard drawings, are revised and fresh standard designs and drawings are made which takes considerable time.

B. Codes, Manuals and Specifications:
Preparation and updating of all codes, manuals and specifications for design, construction and maintenance of bridges are done by the B&S Directorate. The directorate represents Ministry of Railways on all important committees of BIS concerned with bridges and structural design, building materials and construction. The important IRS codes and manuals are as under:-

- IRS Bridge Rules;
- IRS Concrete Bridge Code (Code of practice for plain, reinforced and pre-stressed concrete for general bridge construction);
- IRS Bridge Substructures and Foundation Code (Code of practice for the design of sub-structure and foundations of bridges);
- IRS Steel Bridge Code (Code of practice for the design of steel or wrought iron bridges carrying rail, road or pedestrian traffic);
- IRS Welded Bridge Code (Code of practice for metal are welding in mild steel bridges carrying rail, rail-cum-road or pedestrian traffic);
- Fabrication and erection of steel girder bridges and loco turntables (Fabrication specifications);
- IRS Arch Bridge Code;
- IRS Code of Practice for the Structural Design of Microwave Towers of self supporting type (Self supporting microwave tower code);
- IRS Code of Practice for Fabrication and Erection of Steel Work of Microwave Towers for self supporting type;
- Indian Railways Bridge Manual.

Revision of codes and manuals and any amendment is done with utmost care after detailed investigations and study of the world literature, the proposed amendments are circulated to Railways for comments and then discussed in the Bridge Standards Committee (BSC) meeting. The amendment is done after approval of the Board along with the recommendations of the BSC.

C. Standard Designs of Bridges and Structures: The directorate has issued standard drawings for all commonly used bridges of various spans up to 76.2 m for various loadings in use.
D. **Design of special bridges and structures:** Design of special bridges and structures is also done by RDSO and sometimes it is got done through specialized designs agencies. The design criteria is provided by the RDSO and also proof-checking is done by RDSO. A double cantilever bridge having 120 m box type PSC girder was designed and checked for its dynamic behaviour for road bridge across Brahmaputra at Tezpur in early eighties. Another open web steel rail bridge near Jogighopa across Brahmaputra with 120 m spans for double line MBG loading-1987 was designed by RDSO. The directorate has been designing all important structures including multistoried buildings for IR. However, since eighties, this work is being done by Zonal Railways with the help of design consultants and any assistance required by the Railways is provided by the directorate.

E. **Consultancy:** On reference from Zonal Railways the directorate takes up investigations on field problems on existing bridges due to fatigue, ageing, increase in loads, signs of distress in bridges and structures, investigations are done by testing in field and NDT etc.

F. **Introduction of new technologies:** The following new designs have been popularized on IR due to their advantages-

- **Welded Girders:** Earlier all steel girder bridges used to be riveted type but due to improvement in welding technology, large scale use of welding in bridge girders has been done since seventies due to its advantages.

- **PSC Bridges:** IR was pioneer in building first PSC bridges in fifties and sixties, but due to some shortcomings and inadequate quality control, these bridges posed problem and the PSC use for Railway bridges was abandoned. In eighties, it was realized that the design specifications have now been improved considerably in the light of new knowledge and quality of workmanship in the field of PSC work has improved substantially. The PSC girder bridges are being used extensively abroad. It is much faster to construct bridges of PSC and they are also cheaper than steel bridges. Accordingly, RDSO developed designs and drawings for various type of PSC girder bridges and also provided consultancy to zonal railways for special bridges. Design code and maintenance manual were provided by RDSO for PSC bridges. As a result now most of new span bridges are being provided of PSC.

G. **R&D investigations:** Some of the important R&D investigations are as under:-

**1960-80**

- **Assessment of strength of old masonry arch bridges:** There are about 21,000 masonry arch bridges and culverts on IR most of them more than 100 year old. Static, dynamic and destruction load tests were done by RDSO during sixties over more than a dozen bridges to find out the reserve strength and strength contribution by its various components. Based on these tests, test criterion was evolved by RDSO based on BRS criterion of UK suitable for IR conditions and has been incorporated in IRS Arch Bridge Code. Representative type of arch is tested under a test load usually applied by hydraulic jacks from a loaded bogie frame. Spread and deflection at crown of the arch are recorded and its recovery after removable of the load is checked. If the deflection at crown and spread at springing are within the specified limits and the recovery is complete after removal of the test load, the arch is considered safe for the test load and it is cleared for the load. In addition, ‘Survey and Tabulation Method for Assessment and Strengthening of
Masonry Arches’ was developed by the author which enables to assess the strength of existing arches easily even without load test and suggest measures for strengthening the arch. The test criteria and ‘Survey and Tabulation Method’ have enabled to retain hundreds of old masonry arch bridges particularly on MG to BG conversion projects and have resulted in savings of more than hundred crores of rupees.

- **Investigations for Dynamic Effects on Girder Bridges**: IRS Bridge Rules provided for an impact factor for speeds up to 100 km/h which was based on trials done with steam traction. With introduction of diesel electric locos and their running at higher speeds, it became necessary to conduct trials on different types of bridges at various speeds. The trials were commenced in early 1968 first on Bridge No. 66 of 18.3 m span girders on Varanasi-Zafrabad section of NR. The girders were strain gauged to record bending movements and shear forces at different locations. LVDTs were used for recording deflections. The measurements were recorded under both WP steam loco and single and coupled WDM₄ diesel electric locos at various speeds up to 136 km/h. The following was observed:-

(a) The dynamic augment due to diesel locos are considerably lower than those for steam locos and the dynamic augment even up to 136 km/h are much lesser than those under steam locos. This enabled to clear bridges for introduction of Rajdhani Express.

(b) During trials a resonance phenomena was observed and very high vertical accelerations up to 0.87 g were recorded in the loco cab by means of accelerometers at about 120 km/h. However, it was observed that when the speed exceeds 130 km/h the resonance phenomenon gradually tapers off. An odd run was taken at 157 km/h and running was smooth. This phenomenon was analysed and is reported in RDSO’s Civil Engineering Report No. 129. This phenomenon was occurred only on 18.3 m multi-span bridges.

The tests for dynamic effects have been done on number of other bridges of different spans under various speeds on both BG and MG. Based on the test results provision of dynamic augment has been revised in IRS Bridge Rules. The revised dynamic augments have provided relief in the design loads particularly for longer span bridges and have therefore made it possible to reduce the cost of construction along with permitting higher speeds. Some tests have also been done on ballasted deck bridges.

- **Study of dispersion of tractive and braking forces on bridges into various bridge components including bridge approaches**: This has been a major problem as due to increase in trailing loads with higher horse power locos with improved air brakes etc., the longitudinal forces have been increasing as indicated earlier. Exhaustive trials were done on Sone Bridge of 14×76.3 m with two shore spans of 30.5 m in 1967. The strains and forces were recorded in various bridge components namely bottom booms, bearings, bridge piers, rails both main rails and guard rails and in CBC. The test train consisted of three WDM₄ locos followed by 30 box wagons loaded to a cross weight of 60 t each. The force distribution was recorded under running trains as well as under test train with various conditions such as (i) Sudden application of brakes; and (ii) The maximum tractive effort exerted by the locos placed in the desired position on the test span and box wagons away from the test spans were fully braked. These trials enabled to understand more rationally the distribution and dispersion of tractive and braking forces in Railway bridges.
For plate girder bridges a special type of bearing stool of double ‘I’ section was developed, first of its kind in the world, and was instrumented and calibrated in the B&S Lab and used for further trials on 6×18.3 m Varuna Bridge on Varanasi-Zafrabad section. The trials have been conducted under various conditions on number of bridges and have led to very good understanding of dispersion of tractive and braking forces in Railway bridges.

The author has developed a theoretical method as part of his Ph.D thesis for working out dispersion of tractive and braking forces in Railway bridges taking in to account all track and bridge parameters based on transfer-matrix technique. This method enables to compute dispersion of tractive and braking forces on bridges and is presented as a technical paper ‘LFDISP’ programme by the RDSO. The analysis and the trials have led to several revisions in the codal provisions for dispersion of tractive and braking forces in IRS Bridge Rules. The study also revealed the method for retaining existing sub-structures by replacing existing bearings with suitably designed elastomeric bearings. These have led to retention of hundreds of bridge sub-structure on IR particularly during gauge conversion projects leading to savings of over hundred crores of rupees.

G. Research and development work in recent years:
- Load test on arch bridges;
- Coefficient of dynamic augment in bridges;
- Longitudinal force on girder bridges;
- Assessment of residual fatigue life of early steel/ wrought iron bridges/steel bridges;
- External pre-stressing of MG girder for BG loading;
- High strength friction grip bolts and nuts;
- Measurements of vibration signatures on PSC girders;
- Acceleration trials on bridges for removing the speed restriction on bridges;
- Field trial for FRP sleeper developed by RDSO;
- Field trial in connection with application of AET on Railway bridges;
- Instrumentation of super structure of Rail-cum-Road bridge at Jogighopa;
- Testing of aluminium alloy girder;
- Effect of train actuated vibrations on structures located near the track;
- Development of NDT techniques for measurement of corrosion, cover and mapping of reinforcement of bridges;
- Remote monitoring of bridges using Optical Fibre Technology;
- Continuous scour monitoring of Bridge Pier/Abutment Foundation;
- Revision of fatigue provision in IRS Steel Bridge Code;
- Capability assessment & condition monitoring of bridges for higher axle load; and
- Development of software to calculate Bending Movements Shear force based on actual moving load.

H. Important tests done in recent past:
- **Ganga Bridge:** The Bridge No. 110 upline, is an open web underslung girder bridge of span (25×30.48 m + 1×12.19 m) between Lucknow and Kanpur section of NR. The girders were erected in the year 1926. The bridge was tested for getting Stress - Time history under the running traffic along with the testing of Down line bridge. Some specimens were taken out from the existing bridges for fatigue testing and residual life has been estimated as about
40 years. Fatigue life was also calculated according to BS 5400 Pt. X. (Report No. BS–75 of RDSO).

- **Narmada Bridge**: The substructure made up of steel trestles of Narmada Bridge No. 952/1, span of 6×50.325 m + 4x12.2 m between Jabalpur – Itarsi in WCR fabricated in the year 1927-28. Replacement of substructure of this bridge with suitable RCC structure and foundation was a sanctioned work at a total cost of Rs. 10 crores. One representative substructure was tested by RDSO for assessing the residual life and it was about 200 years (Report No. BS-77 of RDSO).

- **Non Destructive Test of Bridge No. 52 & 53**: Bridge No. 53 (3 × 12.3 m) and Bridge No. 52 on Manasi - Saharsa (MG) section of ECR was having wide cracks on their piers and abutments. NDT were conducted to assess the quality and compressive strength of concrete as well as corrosion level on affected piers and abutments to find out the extent of damage due to cracking and suitability of substructure for BG loading. For Bridge No. 53, NDT revealed that the quality and strength of concrete are more than the design values but the visual observations indicate that either there has been major construction flaw or quality of concrete in patches was very poor, which have given rise to wide cracks. Corrosion analyzer confirms that the reinforcement of the structure is being corroded. For bridge No. 52, compressive strength observed at the bottom side of the pier is very low. Visual observations give a clear sign of honey combing and poor quality of concrete. Therefore strengthening of substructure has been suggested to the Railway to be taken up on priority. (Report No. BS-73 of RDSO).

R&D work done by the directorate has helped to carry increasing axle loads and longitudinal forces (traction & braking) on bridges without rebuilding of old bridges or by retrofitting at a fraction of the cost of rebuilding. It has provided standards designs and drawings for various bridges and structures including special bridges. It has helped introduction of new technologies on IR. It has also rendered valuable advise to all Zonal Railways on problems of bridges and structures.

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*Late Dr N. Ananthanarayana has been very learned, popular and one of the most remembered person in RDSO. He was an IRSE officer who has served RDSO during major part of his service carrier in various capacities starting from Dy. Director to Addl. Director General from where he retired in 1992. He has contributed a lot to the R&D work done in Civil Research particularly Bridges and Structures. While working in RDSO he obtained Ph. D. on Rail Wheel Interaction.*
**General**

This directorate was part of Director/Standard (Civil) since inception of RDSO and the Track Standards work was being looked after by a Joint Director. In 1974, Addl. Director/Standards/Track was made head of the Track wing under Civil Directorate. In 1986, Track Design Directorate, in its present form was established as an independent directorate headed by Director/Standards (Track). Subsequent to large scale mechanisation of track maintenance activities, the subject of monitoring of Track and maintance by machines was separated from Track Design Directorate in 1992 to newly create Track Machine & Monitoring Directorate. In 1995, the post of Director/ Standards (Track) was re-designated as Executive Director (Track).

Main functions of directorate are Research, Design and Development of Rails, Welding Technology, Sleepers, Fastenings, Turnouts, Long Welded Rails, Ultrasonic testing etc. The Track Directorate also provides consultancy to Zonal Railways on the matters pertaining to track, Development and standardisation of new innovations reported by the Railways.

During early period after independence, the operation of IR was with steam traction and the conventional track structure consisting of wooden/ metal sleepers with rigid fastening was considered adequate. Subsequently due to development of Indian economy and industrialization, need was felt for operation of heavier freight trains and higher speed trains at increased frequency, which necessitated a sturdier track structure. In order to keep pace with development, a number of steps were taken by Track Design Directorate for design and development of track components and track structure, which would provide a better resilient track with minimum maintenance effort.

**R&D Activities**

The main achievements are as under:-

- **Earlier work till 1970:** Railway Track on IR consisted of light rails with maximum of 90 lbs/ yard with UTS of 72 N/ mm² with rigid fastenings such as dog spikes, round spikes etc. The rails were 12-13 meters long with fish plated joints. These were not suitable for heavier loads, high density of traffic and higher speeds. As the traffic was increasing and financial resources of the country were limited and import of materials was not feasible, the thrust of R&D was to optimize the use of existing resources with as little inputs as possible. Therefore, to start with the research was essentially concentrated on understanding the track better. Measurement of stresses in the rails due to traffic, thermal changes and speeds were done and the design was modified. A 52 kg/m rail was designed by the RDSO and was used on BG. Extensive laboratory tests and field trials were done by Track Research Wing. Track characteristics including that of its fittings and fastenings were recorded and analysed by strain gauging and transducers under running train loads. These studies enabled to understand the track better. The fishplates were the weakest link and were resulting in fractures. Therefore, longer fishplates of 24 inch were used on BG with improved fish bolts. Rigid fastenings work loose with traffic and speeds, therefore, a number of elastic fastenings similar to
Pandrol clip were tested and introduced on IR. Measured Shovel Packing (MSP) was used with Directed Track Maintenance (DTM) in a big way in sixties and early seventies. Design of concrete sleepers was also taken-up and gradually introduced on IR. The track monitoring was done by track recording cars. Thermit welding was introduced and improved versions were brought about by RDSO. These changes enabled IR to break the speed barrier and introduce first Rajdhani Express on 1st March 1969 with very little inputs.

- **Rail**: The track structure of IR earlier used standard British rail sections up to 90 R sections. These rails were made of Medium Manganese steel having UTS as 72 N/mm². In order to meet the traffic demand, a new profile of heavier rail section of 52 kg/m was developed at RDSO in early nineteen fifties and its regular rolling was started in year 1959. This is the first rail section which was designed indigenously. In 1984-85, the metallurgy of rail was upgraded to manufacture the rails with higher ultimate tensile strength of 90 N/mm². RDSO made continuous endeavor to upgrade the specification to the rails and major breakthrough were achieved with active association of SAIL.

  It was observed that the corrosion is a major problem, which results in premature replacement of rails. Alternate metallurgy of corrosion resistant was developed as a joint effort of RDSO, RDCIS/ Ranchi and SAIL/ Bhilai with controlled alloying by addition of Copper (0.35%) and Molybdenum (0.15%). The trials on SCR and ECoR exhibited better corrosion behaviour of these rails. Further trials of these rails are in progress on NR, WR & SCR.

- **Concrete Sleeper**: Development of indigenous design of concrete sleepers was taken up from early fifties. Various designs of RCC sleepers with twin blocks and PRC sleepers both of pre-tensioned and post-tensioned with various concrete designs were attempted. Earlier there were lot of failures. After extensive trials and satisfactory performance in field, the present design of pre-stressed concrete sleeper was adopted in 1978. The present design for main line BG sleepers consists of M-55 concrete with 18 number 3 ply 3 mm dia High tensile steel strands and weighs about 280 kg. This concrete sleeper has proved to be a landmark in the history of IR track because of its advantages. The sleeper is heavy and lends more stability to track. With elastic fastenings, it offers better gauge maintainability, can be used in track circuited areas, offers very high resistance to fire, more durable and has the largest life span. At present, about ten million concrete sleepers are being manufactured per year on IR.

  Special concrete sleepers have been
developed for turnouts, level crossing, switch expansion joints, ballasted deck bridges with provision of guard rails, sharp curves with provision for gauge widening and check rail, mixed gauge (BG-MG), restricted head room locations etc.

- **Elastic Fastening System:** Development of concrete sleeper necessitated the development of elastic fastening system as the advantage of natural resilience of wooden sleepers was not available with concrete sleeper. The necessary resilience to control wear and tear of rails, sleepers and fastening components have to be provided by the fastening system. IR adopted the fastening system of Pandrol, U.K. (PR 401) in 1968 under patent of M/s Lock Spike, U.K. and manufactured by M/s G.K.W., Kolkata. The first indigenous design of elastic rail clip (Round Toe) was developed by RDSO in April, 1970 and was introduced on IR in 1975. Due to various limitations of round toe clip, the design was modified to provide flat toe and this elastic rail clip, named as ERC MK-III, was introduced on IR from July, 1987. This elastic rail clip is widely used on IR now. Along with elastic fastenings, other fastening components viz rubber pads, liners of various designs and specifications have been developed and are being widely used. Continuous efforts are still being made to upgrade the fastening system. Development of composite rubber pad with two layers – one harder and the other softer and Elastic Rail Clip Mark-V are important recent developments.

- **Turnout:** Development has been done in turnouts and its components. High speed turnouts with better riding qualities of 1 in 16 and 1 in 20 turnouts were developed along with improvements in the existing layouts of 1 in 8½ and 1 in 12. Stud type switches which were weak link were replaced with overriding switches. Now, non-overiding thickweb switches are being used to provide full complements of fittings in stock rail.

Initially, crossings were of fabricated type, in which, vee is made by joining point and splice rail with the help of turned bolts. Now, monolithic cast manganese steel crossing (CMS Crossing) has been developed, which is free from inherent problem of fabricated crossing. CMS crossing was introduced in late sixties, however indigenous manufacture was sucessfully started in 1985. Life of CMS crossing is also more than fabricated crossing. RDSO has recently developed weldable CMS crossing also.

- **Continuous Welded Rails/Long Welded Rails (CWR/LWR):** IR has moved from conventional fish-plated track to Long Welded Rails/ Continuous Welded Rails
over the last few decades. Welding of rails has been necessitated on economic considerations coupled with technical advantages that a welded track offers such as better maintenance, enhanced comfort and reduced fuel consumption. Rails were initially welded into 5 and 3 rail panels, called short welded panels (SWP) as the first stage of development. RDSO has contributed significantly by way of carrying out basic work including determination of lateral and longitudinal ballast resistance of various track structures, which helped in development of LWR Manual.

In order to continue the long welded rails in turnout area, detailed studies have been carried out recently and a scheme for carrying LWR through points & crossings has been framed using thick web switches, Weldable CMS crossing and ERC Mk-V. Works are going on to allow laying of LWRs on various types of bridges.

- Development of Welding Techniques: In late fifties, conventional Thermit welding process was developed on IR, in which green sand silica mould was used to provide casting and preheating cavities. Conventional preheating process for in-situ welding on track required about 1¾ hour time to complete execution of one joint (due to higher pre-heating time of 30-40 minutes and preparation of green sand mould at site) and with the increase of traffic it became quite difficult to get the sufficient engineering block for execution of thermit joint in track. SKV technique i.e. short preheating process with preheating time of 8-12 minutes was developed in early eighties, which used pre-fabricated moulds.

During late nineties, to further reduce the preheating time and to improve the quality of welds, welding technique with compressed air petrol preheating was developed. The technique reduced preheating time to 4 - 4½ minutes. The lesser width of HAZ resulted in improved service life of welds.

In recent past, AT welding technique with three piece mould, 75 mm wide gap AT welding technique, 60 kg/ 52 kg (90 UTS) combination joint AT welding technique have been developed.

- Development of Ultrasonic testing Techniques for rails and welds: Ultrasonic testing of rails was introduced over IR during early 1960s. During the last 40 years of its existence, a large number of testing procedures, specifications, guidelines and criteria have been issued from time to time based on the experience gained. In the meantime, the scope of testing has been extended to Alumino Thermic (AT), Flash Butt (FB), Gas Pressure (GP) welded joint, SEJs and Points & Crossings.

The advent of fracture mechanics concept coupled with state of the art steel making technology has thrown open a new dimension in the periodicity of ultrasonic examination. The rate of crack propagation and fracture toughness characteristics of rails can be experimentally found which determine the critical crack size.

Based on the above knowledge and experience, it was considered necessary to assimilate the entire information on ultrasonic examination of rails and present it in the form of a manual so as to guide the ultrasonic personnel in testing, interpretation and decision-making. Accordingly, the first edition of the USFD Manual was prepared and issued during
The main feature of the manual was introduction of ‘Need based concept’ on all BG routes of IR. In need based concept, the optimum cost of maintaining rails in track can be achieved since the inspection frequency is made dependent on the incidence of the defects so that the inspection resources are not unnecessarily frittered away on sections where the condition of rail is sound and its performance in track does not warrant frequent inspection. In 2006, all the routes of IR have been brought in the periphery of ‘Need based concept’.

- **Rail stress calculations methodology:**
The rail stress calculation method assumes rail as beam on elastic foundation. The concept of adjoining load and ‘Speed Factor’ to take dynamic loads into account are also applied. Fundamental investigations on track stresses were initiated by the RDSO in 1963 and vast data was collected with regard to ‘Track modulus’, vertical bending stress in rail, speed factor and fish plate stress. As the value of track modulus assumed in past was too low and speed factor was not also verified by any stress measurements under Indian conditions these initiatives provided then realistic values. Further investigation for speed factor and ‘Track modulus’ were carried out in 1977. Stresses in fishplates, stresses in rail holes of fish-plated joints, pressure on the formation, rail contact stresses etc., were introduced in mid-seventies. RDSO documented and circulated it in 1979 which used double track modulus method (modified with higher value) and Blondel’s limit as limiting lateral load. The limit of lateral load as per Prud’hommé’s limit was introduced in mid eighties providing relief in rail stresses.

Due to upgradation of track structure and rolling stock, necessity was felt to review the rail stress calculation methodology. During 2004-05, action was taken to revise/revalidate values of track modulus and dynamic augment by actual field trials. The values have been updated. With the available knowledge, track structure for 25 t axle load was finalized marking the beginning of IR ushering into heavy axle load regime.

- **Ballastless track & Washable Aprons:**
During construction of Metro Railways, Kolkata, a third rail concept for feeding electric traction power at rail level was required. This concept necessitated removal of ballast from track. Due to this requirement, three designs of ballast-less track were developed.

In order to meet the requirement of washable aprons at platforms, the drawings for Ballasted Washable Apron and Ballastless Washable Aprons have been developed.

- **Development of alternative to Wooden Sleepers for Steel Bridges with open decks:**
On steel bridges with open deck, bridge timbers/ steel channel sleepers are used. Due to acute shortage of timber, it became essential to develop alternate designs for the sleepers. For this purpose, a project of development of FRP sleeper was also taken up. After conducting laboratory tests, field trials were conducted on NR, CR, SER & SR. As field trial results were not encouraging, RDSO continued its efforts for alternate product. Composite sleepers has been successfully tried, efforts are in progress to develop more composites for the purpose.

In order to provide steel channel sleepers more extensively, the arrangements of insulated fittings for steel channel sleepers on bridges for track circuited areas and zero toe load fastening system has been developed.
Codes, Manuals and Standards:

The track design directorate lays down the standard specifications of important P-way components, which are reviewed from time to time. The specifications are issued as provisional initially. Subsequently, based on field performance and review, the specifications are standardized and issued with fixed serial number. The directorate has issued 34 important specifications for track components along with a number of provisional specifications. The following important manuals have also been issued:

List of Manuals

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<th>S.N.</th>
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Commendable work has been done by the Track Directorate, first till the end of seventies to adopt appropriate technology for permitting higher speeds and loads on existing track structure by introducing MSP, DTM, welding of rails, revision of fish plate design, de-hogging of rail ends etc. This was done based on instrumented field and lab trials on track. Simultaneously heavier track structure with PSC sleepers with elastic fastenings, LWR & CWR, improved turnout design along with revision of codes, manuals and specifications has been done. These provide for modern track suitable for heavy traffic and high speeds. The directorate is engaged in continuously upgrading the technology for track components. and track maintenance practices for which number of project are in progress including trials of various components.

Late Padmashri P.N. Bhaskaran Nair was JD Research (Civil), RDSO from 1967 and in that capacity he undertook several innovative studies to improve the track structure and the quality of maintenance of track on IR. Prominent among these was a new design for rail to sleeper elastic fastening named as IRN-202. This fastening was meant to absorb vibrations, prevent creep and improve the maintainability of the track. He also made some innovations in the measurement of recording of track and vehicle parameters by means of ‘Track Recording-cum-Research Car’ and simultaneous analysis of the data by means of an on-board computer. After a stint of three years in Railway Board, Sri Nair returned back as Director Research (Civil), RDSO. In recognition of the outstanding contributions made by Sri Nair, he was honoured with the award of Padmashri by the President of India in 1973.
General

The directorate is working under Executive Director/ Track Machine & Monitoring since 1995. Earlier it was headed by Director Research (Track)/ Additional Director (Track) since 1974. Prior to 1974, the work was looked after by Joint Director under Director Research.

R&D Facilities and Activities:

A. Laboratory and its contribution: The Track Research laboratory has been in existence since RTRC days. It has been constantly modernized and provided with latest testing equipment. The lab in the present building came into existence in early eighties. It has the following testing facilities:

- Static and dynamic tests on track components;
- Fatigue testing of track components on hard bed and ballasted bed;
- Fatigue testing of track components on Hydraulic Pulsator;
- Measurement of toe load for elastic fastenings;
- Evaluation of stress at critical locations for track components;
- Calibration of helical springs for mechanical toe load measuring device;
- Verification of calibrated load cells for electronic toe load measuring device;
- Creep resistance test;
- Pullout test for insert and dowels; and
- Calibration of Oscillation Monitoring System of Zonal Railways.

Apart from the testing jobs, training is imparted to staff and officers of Zonal Railways for proper inspection of ERCs to ensure quality control.

Salient Testing Equipments:

- Rail Track Panel Fatigue Testing Equipment: The main functional characteristic of this equipment is to simulate dynamic loading environment as occurring in field by a rolling wheel axle set. The equipment consists of computer controlled hydraulic pulsator system for controlled operation of actuators to generate necessary loading environment. The hydraulic system consists of hydraulic power pack, actuators, servo valves, servo blocks and data acquisition system. Dynamic loading capacity of vertical actuator is +250 kN and lateral actuator is +100 kN. The load can be applied up to 20 Hz. Displacement range of both actuators is +50 mm.

Universal Testing Machine: The maximum loading capacity of the Universal Testing Machine available in track lab is 20 t. It can work in three different loading ranges of 2 t, 10 t and 20 t.
• **Toe Load Measuring Device (TLMD):**
RDSO has developed toe load measuring device for measurement of toe load in the field. Sri B.Rajaram, the then JD and Sri H.S.Mohindra, the then SRE (TM) contributed for its development. The mechanical type of TLMD consists of a pre-calibrated helical spring resting on a base plate supported by three legs. Two legs rest on a sleeper and one on railhead. The spring is compressed with the help of a rotating handle and link hanger takes its upward reaction. The compression of the spring can be read on graduated scale and corresponding toe load can be assessed from the calibration chart.

Electronic toe load measuring device

TM directorate has further developed low weight electronic toe load measuring device in order to measure toe load in the field faster and more accurately. Sri H.S.Mohindra, the then SRE, Sri Ramesh Sharma, SSE (Engg.) and Sri Deepak Sharma, JE (Mech.) contributed for its development. This device basically consists of a pre-calibrated load cell and a LCD unit, which gives display of toe load directly on the screen. Load cell capacity is 2000 kg.

• **Hydraulic Pulsator:**
Hydraulic Pulsator simulates the dynamic loading conditions. This machine applies vertical and horizontal forces of fluctuating values on an element of track assembly to represent forces exerted by wheels. The tilting effect of the rail, horizontal thrust on gauge face and high stresses in the fastening system are simulated under this equipment. Maximum load of 25 t can be applied in static condition. This machine is capable of developing a vertical fluctuating force of 2 t to 20 t at a frequency of 250 cycles per minute. By the use of suitable load bridge, the lateral force on each railhead is developed complementary to the vertical force.

**Projects Undertaken**

Track lab is being used for carrying out different types of the tests required for improvement of track and its equipment. It is also used for study of effect of axle load on formation including blanketing material etc. It has been used for tests sponsored by the UIC. Under Joint Research Project of UIC on Rail Defect Management, 19 rail samples (8 samples from RTRI Japan, 4 from India, 3 from TTCI, USA and 4 from SPOORNET, South Africa) were tested in 2002 and the track lab earned Rs. 90 Lacs worth of foreign exchange for testing in this project.
**Field Trials**

Track Research has been conducting field trials along with recording of stresses, deformations and various other parameters under field conditions for various types of tracks, their conditions and different components. Studies were conducted in sixties & seventies to determine track modulus for different type of tracks and the track designs were based on these values. With modernization of track with heavier concrete sleepers, elastic fastenings, more ballast cushion, mechanized maintenance, improved formations, necessity was felt to again study the track modulus in the field.

Field trials were conducted in static condition to determine the track modulus value of the present track structure prevailing on IR. Data obtained during trials were analyzed to determine appropriate value of track modulus.

**B. On-Track Machines:** With the introduction of concrete sleepers with CWR/ LWR tracks, mechanized maintenance of track became necessary. With increase in traffic and axle loads, complete length of Indian Railway track is planned to be covered with mechanized maintenance. Large number of track machines of improved versions are being procured and introduced on IR. The role of machines in track maintenance started towards the beginning of sixties and the first four on-track tampers were purchased during the period 1963-66. Later 12 machines (06-16-SLC) manufactured by M/s Plasser & Theurer were purchased in 1968-69. The subsequent batch of 12 machines of model No. 06-16 USLC was introduced in the year 1972-73. Other track machines like PQRS (for relaying of track), Unomatic and Duomatic, points and crossing tamping machines were also introduced. There were about 300 machines of different types of track maintenance and track laying activity on IR in 1996. Subsequently more track machines have been procured by IR and at present around 500 track machines of different types, makes and series are working on IR and most of these machines have been imported without any transfer of technology. The main work s done by RDSO are as under:-

- The directorate has issued several manuals for proper working of On-Track Machines including maintenance schedule manuals, inspection checklist, troubleshooting manuals for different type of machines viz Tamping Machine (CSM 09-32), Points & Crossing tamper (UNIMAT), Ballast Cleaning machine (RM-80), Shoulder ballast Cleaning Machine (FRM-80), DGS-62N, BRM, Duomatic (08-32), Unomatic (08-16) and Tamping Express (09-3X);

- During the working of large on-track machines in the field, various problems faced by the Zonal Railways are referred to RDSO. These issues are technically examined in detail and solution/ suggestions are given to the Zonal Railways.

- Final and provisional speed certificates for conducting oscillation trials and operation of the machines are issued by the directorate to Zonal Railways;

- It makes detailed technical specifications of the machines being procured by IR;

- Field studies are done by the directorate to assess the effectiveness and efficacy of various types of machines are also carried out and recommendations are sent to Zonal Railways.

**C. Small Track Machines:** With the introduction of heavier track structures with LWR/ CWR and subsequent mechanization of track maintenance on IR, the small track machines are now essential part of the track maintenance equipments. Thirty-seven
different types of small track machines have been developed for IR and 8 different machines are under trial order.

- A small track machine manual was written, published and finally distributed to Zonal Railways in 2005-06. This manual lays down the organisational set required on the Railways, powers to deal with procurement and maintenance and other technical details of small track machines.

**New Development:** The following small track machines which have been recently developed and the Railway Board have approved them for trials.

- **Heavy Duty Hydraulic Extractor for Jammed ERCs:** It can extract jammed ERCs with a force of 30 t with extraction stroke of 40-50 mm in 5 minutes including fixing and removal of the machine.

- **Hand Operated Weld Trimmer:** This tool is useful for trimming the welded joints with better finish and in much lesser time and one sheer blade can trim minimum of 200 joints.

**D. Track monitoring by track recording cars:**

- There are four track recording cars with RDSO which are run and maintained by the directorate for the statutory monitoring of different routes of IR as per frequency specified in Indian Railway Permanent Way Manual (IRPWM).

- The track recording system needs continuous development and upgradation because of change in technology and the field requirements. This work is also carried out by this directorate.

- **Upgradation of two TRC’s (TRC 7973 & 803):** Two TRC’s have been upgraded and microprocessor based systems have been installed in TRC 7965 and TRC 7966. These TRC’s can record various track parameters including cross level at speeds between 20 km/h to 110 km/h. Vehicle ride parameters are also recorded in these TRC’s.

- This directorate has one track recording car which is fitted with rail profile measurement and analysis system. This is laser based, non contact rail profile measuring system. It provides accurate measurement of rail head profiles in real time, lateral & vertical wear, rail rollover, lip flow and gauge. On board computer system analyzes the acquired images and gives various derived parameters. Speed band of recording is 20 km/h to 160 km/h. On board computer process information and on line reports are generated in addition to on board display of profile of left and right rail, lateral & vertical wear, rail
inclination, track gauge, route features, location etc. on visual display unit.

E. **Track Management System:** Development/ Upgradation, installation & commissioning of Track Management System on various zonal railways including training of officials in operation and use of the system is done by the directorate.

F. **Testing of track components:** Various track components like sleepers, ERC clips, rail, welds etc. are tested in Track Lab during their development stage using the facilities of track panel fatigue testing equipment, hydraulic pulsator, rail tensioning system, Universal testing machine etc.

The directorate has contributed significantly in improving the maintenance of track by ensuring its proper maintenance with track machines after regularly monitoring the track condition by track recording cars. It has also brought out several improvements in track recording cars. It has provided detailed guidance by issuing detailed instructions including manuals and specifications etc. to field staff for maintenance and operation of track machines. There are about 500 track machines on IR for mechanized maintenance of track. It has developed track management system for IR.

*Sri Desh Deepak while working as Dy. Director/ Joint Director in seventies and eighties for over 9 years in RDSO, did remarkable work for bringing about microprocessor based improvements in track recording cars, track research cars and other equipments. He contributed significantly for the setting up of microprocessor based facilities in RDSO.*
Geotechnical Engineering Directorate

**General**

Geotechnical Engineering Directorate was started in the year 1974 as a part of Civil Research Directorate as Formation Engineering. It was renamed as Geotechnical Engineering and became an independent directorate headed by Additional Director/ Director/ Executive Director since 1979. The directorate essentially deals with:-

- Advice on all matters concerning geotechnical engineering to Railway Board;
- Framing and updating Guidelines/ Manuals/ Specifications;
- Applied research in Geo-technical Engineering;
- Consultancy on special GE problems to Zonal Railways;
- Monitoring quality and progress of formation rehabilitation;
- Overseeing the function of G. E. Organisation of Railways;
- Training of railway personnel in Geo-technical Engineering;
- Super check of quality work of formation in construction projects, on the orders of Railway Board.

**Laboratory**

Soil test lab has been in existence since early seventies and has been full modernized with all sophisticated equipments. Apart from normal soil testing facilities like index properties, particle size distribution, triaxial shear test, direct shear test apparatus, modified proctor test. There are state-of-art equipment like ‘dynamic triaxial shear apparatus’ to determine threshold strength of soil under field simulated dynamic condition, ‘laser particle size analyser apparatus’ which is used for analysing soil particle size and ‘nuclear denisty moisture gauge apparatus’ to determine in-situ density, moisture content and degree of compaction of soil. The Lab is also equipped with computerized static triaxial test apparatus and computerized consolidation test apparatus for fast and accurate processing of data.

The Lab also possesses a Ground Penetration Radar (GPR) System which has been imported from USA. Very few labs in India possess this sophisticated equipment. GPR is useful for determining the ballast penetration profile in formation to plan its strengthening and rehabilitation measures.

Lab is equipped with all necessary equipments, most of which are upgraded with computerized processing system.

**R&D Activities**

R&D contributions have lead to facilitate operational improvements, increased safety and economy by reducing track maintenance efforts, allowing increase in axle loads with well designed and/ or strengthening of weak formations, permitting increase in line capacity on well designed formations with increasing trailing loads and at higher speeds with more passenger comfort due to smooth riding etc. The main activities can be subdivided into the following:-

- Consultancies to Zonal Railways for specific problems after detailed investigations at site and lab testing of soil samples.
- R&D investigations leading to revision of specifications;
Quality Audit/ Certification of earthwork in new constructions;
- Manpower development and training.

**Consultancy to Zonal Railways**

On reference from Zonal Railways for weak/unstable formation or other geotechnical issues, remedial measures are suggested after investigation as sites and testing of soil samples in GE Lab at RDSO. These have been of vital use to the Railways. Since year 1979, about 230 consultancies has been rendered by Geotechnical Engineering Directorate. The following consultancies give an idea of the nature of work done during various periods.

**1960-1980**

Some of the field problems were as under:-
- **Foundation problems:** Bearing capacity of soil for foundation of OHE structures on Mughalsarai-Kanpur section; New station building of Mahendrughat, NER; Determination of depth for well foundations for different bridges on Lakheri-Bayana doubling project of WR; Foundation for expansion of Durgapur Steel Plant etc.
- **Stability of embankments and cuttings:** Slips of banks between Pasraha-Maheshkhhunt section of NER; Construction of an embankment in the little Rann of Kutch, Jhund-Kandla, BG, WR; Failure of embankment of mile 139/14 between Vedcha and Amalsad on Bombay Division, WR etc.
- **Other investigations:** Investigations on foundation of buildings in black cotton soil and development of soil pressure cell to measure the pressures on formations in a running track.

**1981-1999**

Some of the activities were under:-
• **Construction of high railway embankment over soft marine clay:** The embankment designed by following the latest concept, was opened to goods traffic. The observations of the instrumented portion of the bank were continued to ascertain the rate of dissipation of pore pressures. On the basis of the experience, a 10.5 m high embankment on marine clay siding was designed for the Rashtriya Chemicals & Fertilizers in Colaba district.

• **Stabilization of black cotton soil embankment by lime treatment:** An indigenous method was evolved for under-traffic treatment of expansive soils by injecting lime slurry into the formation under pressure. Successful trials were made at four locations on SCR and CR and a report giving the efficacy of the technique was published.

• **Mechanics of track ballast:** Lab trials were conducted to evolve a rational method to determine the depth of ballast and sub-ballast for achieving economy.

• **Soil exploration and design of foundation for Brahmaputra Road Bridge near Tezpur in Assam:** Soil exploration work for the bridge foundation and approaches were done. The design of well foundations, approach bank and guide bund was done by taking into account the dynamic analysis and liquefaction studies which were done by Roorkee University.

• Soil exploration and design of well foundation, guide bund and approach bank for the Railway bridge across Gandak near Chhitauni in NER; Soil exploration and design of foundation for microwave towers on Delhi-Bikaner Microwave link in NR and at Lucknow for NER; Soil investigation and recommendation for stabilization of weak formation at 16 stretches on the Zonal Railways.

**2000 onwards**

The following consultancies were provided:-

• Rehabilitation of weak formation between Tanguturu and Ongole-Karavadi stations on Gudur-Krishna Canal Section, Vijayawada Division, SCR;

• Geotechnical investigations and remedial measures for new BG line, Tamluk-Digha, SER;

• Unstable formation between Kamal and Ambala stations on Delhi-Ambala Section, NR;

• Rehabilitation of weak formation between Lucknow and Mailani stations, Lucknow Division, NER;

• Rehabilitation of unstable formation between Kothar and Keshavganj stations on Ajmer-Mahesana Section, WR;

• Rehabilitation of weak formation between Barauni and Katihar stations, NER;

• Rehabilitation of unstable formation between Gaur Malda and Malda Town Stations, ER;

• Aluminum Alloy Girder for Formation Rehabilitation with permissible speed of 20 km/h and blanket depth up to 1.2 m with progress of 300 - 350 m per month.
R&D investigations leading to revision of specifications:

- Ballast is an important component of track and its specification are being revised from time to time along with increase in loads and speeds. The specifications were framed in April 1997 which was revised in 1999-2000 and again in 2003-04 for higher axle loads.
- Fly ash was permitted to be used as fill materials for construction of embankment on Tamluk-Digha section which was proposed to be used by CAO(C)/SER after detailed investigations.
- Report on technical and financial viability of provision of Blanket on formation;
- Design of formation for frost resistance;
- Specifications for mechanically produced Blanket material.
- **Evaluation of various methods of formation rehabilitation on IR:** Large lengths of unstable or failed formations exist on IR, which are to be rehabilitated and strengthened for incipient heavy axle loads and increased GMT. Various methods have been tried in past on IR as well as other World Railways such as provision of blanket, partial blanket, LSPI, cement grouting, vinyl drains, sand piling, provision of geotextiles etc. Some of these have not proved to be effective and economical in the long run. After detailed study, a Report No. GE:39 on review of various methods was formulated and issued to Zonal Railways in March 2003.
- **Guidelines for earthwork in Railway projects 2003:** Based on the experience gained over the years and update knowledge and the advancement in geotechnical field pertaining to railway formation, ‘Guidelines for Earthwork, 1987’ were revised along with unification of various guidelines and after approval of Railway Board, the guidelines titled as “Guidelines for Earthwork in Railway Projects” No. GE:G-1, July 2003 was issued to Zonal Railways on 28.08.2003.
- Standard test procedure on blanket material used on railway formation;
- Booklet on geotechnical testing for railway engineers for quality control.
- **Prefabricated vertical PVC drainage system for construction of embankment on compressible soft soil:** Traditional techniques for embankment construction on soft soils are slow and time consuming, due to which some times the field engineers to take recourse to short cuts which lead to settlement/failure of embankments. Now very sound techniques are available for achieving rapid consolidation of soft subsoils. The technique using Prefabricated Vertical Drain (PVD) provides quick, economical and reliable means for accelerating the rate of consolidation of soft soil by facilitating drainage. RDSO have conducted detailed literature survey on this subject and consulted the industrial leaders in India and abroad for preparation of study report on this subject. Report No. GE:R-68 issued to Railways in December 2004.
- Guidelines on erosion and drainage of formation;
- Guidelines for construction on soft soils;
- Guidelines for cuttings;
- Design of reinforced earth structure;
- Formation rehabilitation using C.C. Crib/ Cube and rail cluster method;
- Guidelines on temporary and permanent restoration of embankment after breaches and washouts.

The above works have been continuing for the past several decades and
modifications in the procedures, construction materials and specifications have been made based on field and laboratory trials and study of the literature. The following important guidelines and specifications have been issued by the GE Directorate:-

- Handbook of soil engineering for railway engineers (June, 1985);
- Guidelines for earthwork in railway projects (GE : G-I, July 2003);
- Guidelines on erosion control and drainage of railway formation (GE : G-4, March 05);
- Guidelines on soft soils-stage construction method (GE : G-5, June 05);
- Guidelines for rehabilitation of existing weak formations (GE:G-6,June 05);
- Guidelines on temporary and permanent restoration of embankment after breaches/washouts (GE : G-7, July 05);
- Guidelines for cuttings in railway formations (GE : G-2, August 05);
- Specification for track ballast with Correction SlipNo.1 (GE:IRS-I, June 04);
- Specification for mechanically produced blanketing material for railway formation including guidelines for laying (GE : IRS-2, August 05 (Final));
- Specification of standard test procedure on blanket material used on railway formation (GE : IRS-3, December 04);
- Booklet on geotechnical testing for Railway engineers for quality control (GE : G-3, December 04).
- Guidelines on Application of Jute Geotextile in Railways Embankment & Hill Slopes has been prepared.

Quality Audit/ Certification of Earthwork in New Constructions:

Quality audit of earthwork on construction projects of Indian Railways used to be undertaken by this directorate. Therefore, stage inspections were carried out during execution of work. Also, RDSO used to certify quality of earthwork before Railways applied to CRS for opening of new sections for public carriage.

Quality audit by RDSO had helped substantially in improving quality of earthwork in formation on new constructions & in many instances, new lines were opened for traffic at relatively higher speed up to 100 km/hr or more. As per directives of Railway Board (vide letter no. 2004/W-1/SR/GC(E) dated 31.05.04) certification of quality of earthwork by RDSO on construction projects is no longer mandatory with effect from June, 04. Quality audit is now carried out on the orders of Railway Board.

From 1999 to 2005, total 118 certificates were issued covering a total length of about 1655 km of new lines.

Manpower Development and Training

Training of field staff in geotechnical aspects is a major thrust area and this directorate is organizing regular training courses, once in two months for Works Supervisors at RDSO/ Lucknow. Earlier in nineties, geotechnical courses of two week duration were organized once/twice in a year at Civil Engineering Training Academy (CETA), Kanpur, IRICEN Pune & various Zonal training Centers at Secundrabad, Udaipur etc. Since July, 2002, every year about five to six training programmes of one week duration on Formation Rehabilitation & Quality Control is being organized at RDSO itself to train field supervisors of various zonal railways. Since 2002, 22 such courses have been conducted and 306 supervisors have been trained.
Signal Directorate

General

Directorate is working under Sr. Executive Director (Signal) since 2000. Earlier it was headed by Executive Director/ Director Standards (Signal) since 1973. Prior to this, Signal Wing was working under Director Standards (Civil).

Signal Directorate has been designing, modifying and introducing various types of signalling systems on IR keeping in view the latest developments. After developing appropriate designs, prototypes are made and testing is done. It has also been improving the existing equipments with a view to save foreign exchange, making it more safe and reducing cost of maintenance. It also deals with the preparation of specifications for signalling equipments and its periodical revision and updating in the light of field experience and also latest development in the state of the art technology. In addition to the above, this directorate renders technical consultancy and advice on various problems arising on Zonal Railways.

Signal Testing Lab

A Signalling Equipment Development Centre has been set up in the Signalling Testing Lab. Here working systems including SSI, digital axle counter, AFTCs, block instruments, LED signal lamps etc. are available. In addition, equipments developed by RDSO, such as signalling relays, polycarbonate lenses, triple pole double filament lamps, power supply equipment etc. have also been displayed. This centre is being used for various testings at developmental stages and for further improvements in the design of various signalling systems. There are two Labs namely (1) Indoor Signal Equipment Lab and (2) Heavy Signal Equipment Lab.

1. Indoor Signal Equipment Lab: It is equipped with full testing facilities for power supply equipment including Solar Photo Voltaic Panels, Signal lamps & lenses, relays both metal to carbon and metal to metal contact type and environmental testings as per ISO:9000. The Lab is also equipped for testing of electronic and microprocessor based equipments like Solid State Interlocking, Block Interface for Optic Fibre Cable, Audio Frequency Track Circuits etc. Climatic tests are conducted on all signalling equipment, simulating field conditions of rain, heat, humidity, corrosion in coastal areas and other conditions likely to be encountered during the usage of the equipment.

![Signalling Equipment Development Centre](image_url)

2. Heavy signal equipment laboratory: This Lab is equipped for testing of all types of electro-mechanical signalling equipment like signal machines, point machines, electric point detector, electric key transmitters,
SM’s slide frames, primary cells, all types of signalling cables and track fittings related to signalling gears. There is a small signalling yard adjacent to Lab having three turnouts including one thick-web high-speed turnout. This is used for testing of point machines. The Lab is provided with requisite facilities of conducting type tests including performance, endurance tests on all above types of signalling equipment.

**Facilities**

The two labs combined together have following main facilities for testing:-

- Environmental Testing with Programmable Environmental Test Chamber; Dry heat chamber; Cold chamber; Rain chamber; Salt mist spray chamber; Dust chamber; Mould growth chamber; and Recovery chamber.
- Software development and validation;
- Lens & Roundels;
- Relay testing;
- Power supply equipment testing;
- Optic equipment testing;
- Signal lamp;
- Cable testing;
- Electro-mechanical equipment testing.

**R&D Activities**

Directorate has played active role in indigenous development of several signal equipments and has brought out several improvements in the signalling system and their equipment to achieve economy and safety keeping in view the requirements of line capacity, high speeds and latest technology available abroad. These developments have been a continuous process since inception of RDSO. The main items are as follows:-

- **Indigenous development of Electric Point Machine:** Point machine was developed indigenously and introduced in 1963. Based on the experience gained in field, its specifications were revised first in 1990, second time in 2002 and further in 2005.
- Development of Electric lamp;
- Roundels and lenses for signals;
- **Development of LED Signals:** The development was completed in April 2002. The LED signal consumes less than 50% power as compared to earlier signal lamps and requires only one type of lamp proving relay for all types for LED signals. These are highly reliable and have no problem like fusing of lamp filaments. These have longer life of about 10 years. LED signals have better signal visibility, do not require focusing and are retrofittable in existing CLS housing. These signals enable drivers to run trains at maximum permitted speed with much better confidence due to better visibility. Thus these signals enhance safety with better train operation.
- Development of maintenance free non-corrosive Apparatus Case;
- Development of FRP Colour Light Signal housing;
- Development of Route Indicator Direction type;
- Development of Insulation Rail Joint;
- Development of PBT Terminal blocks;
- Development of Power supply equipments for signalling;
- **Development of Integrated Power Supply (IPS) system:** It uses a single battery and overcomes drawbacks of conventional power supply arrangement such as frequent interruptions, low/ high voltage & frequency. It provides integrated, efficient and uninterrupted power supply for signalling equipment. It prevents blanking of signals which occur due to power failure and enhances safety in train running. It provides economy by reducing requirement of batteries. In Non RE area further economy is achieved by reducing hours of DG set running.
- Electric lifting barrier with hand generator;
- Train Actuated Warning Device (TAWD);
- Development of low maintenance lead acid secondary cell;
- Indigenous development of ‘Q’ series metal to carbon relays;
- Development of SIG contacts;
- Development of universal lamp proving relay for all types of LED signal;
- Development of metal to metal relays;
- Development of fail safe electronic timer;
- Development of electronic flasher device;
- Development of exothermic weld material for track circuit applications;

**IPS system**

- **Development of Indigenous Block Instruments:** Earlier imported block instruments were being used by all Railways. RDSO developed following types of block instruments during past 50 years for single line & double line which are in use on IR:-
  (a) Token type Block Instrument (Neal’s Ball Token);
  (b) Single Line Tokenless Block Instrument (Push button type);
  (c) Single Line Tokenless Block Instrument (Handle type); and
  (d) Double Line Block Instrument.
- Development of Analogue axle counter; Multi entry axle counter; Universal axle counter; Digital axle counter; Multiple section digital axle counter; Block proving by axle counter (Double Line); Block proving by axle counter for single line; Block proving by axle counter with SSDAC; and Solid State block proving by axle counter (Digital);
- Networked Data Logger;
- Development of Universal Fail-Safe Block Interface (UFSBI);
- **Indigenous Development of Electronic Interlocking:** A project to develop 2 out of 2 hardware architecture based Electronic Interlocking was started
at IIT, Delhi in July, 1983. Apart from RDSO in this project, IIT, Delhi and two industries M/s DCM and M/s CEL were also associated. The design of the system was evolved in March 1985 and a prototype sample based on this design was fabricated in year 1987. The prototype sample was installed at Brar Square Station of NR for field trials. Based on field trial results, it was decided by the Railway Board to manufacture further models incorporating necessary improvements. M/s DCM and M/s CEL fabricated two field models. The prototype fabricated by M/s DCM was installed at Duskheda Station of SER in July, 1993 and the other model fabricated by M/s CEL was kept at RDSO for demonstration and training purposes. On successful field trial at Duskheda station, the same was provided at the station in stand alone mode in October, 1995. It was called as Solid State Interlocking (SSI), Mark–II. The technology was transferred to M/s Crompton Greaves Ltd., based on which they also fabricated one SSI equipment which was provided at Bhadli Station of CR in December, 1995 and provided in stand alone mode in March, 1997. M/s RPIL who had taken over the Railway business of M/s DCM in December, 1993 fabricated one more system which was installed at Uppugundur Station of SR in 1998. SSI Mark-II has been subsequently renamed as Safelock.

Manuals

Telecom Directorate

General

The Directorate is working under Executive Director (Tele)/ Director Standards (Tele) since 1987. Earlier it was working under Director Standards (S&T). The directorate deals with the design, standardisation and other R&D activities concerned with telecommunications for IR. It has a Telecom Lab for in-house testing and investigation and also conducts field trials.

Telecom Laboratory

Telecommunication Lab came into existence in 1987 prior to which it was a part of Signal Lab. It was renovated in 1999-2001 with addition of Optic Fibre Communication (OFC) equipment testing and measuring facility with air-conditioning of the main testing area. It is equipped with testing and measuring equipment, test bench and climatic chamber and other testing equipments.

The Lab has been used for the following main activities:-

- Design development and testing of Train Traffic Control Equipment used in RE and non-RE Areas;
- Testing of VHF, UHF and Microwave equipment and their parameters in the Lab as well as in the field;
- Testing of OFC equipment, measurement of various parameters as well as design and development of OFC accessories;
- Design and development of safety equipment like Voice Data Logger for Control Circuit; L.C. Gate Control equipment with wired and wireless data communication and Private Number exchange facility; Auto dialing system from emergency socket in RE areas; Power Supply system for way station control telephone; Voice Amplifier equaliser system for Quad Cable VF communication system;
- Calibration and testing of measuring equipment from other directorates and maintenance of up to date calibrated master testing and measuring equipment.

R&D Activities

Main developmental activities which have made considerable impact on IR communication needs are as under:-

1962-1970

- Developed loud-speaking telephones for Section Controllers and Single Push Button headquarter selective ringing equipment with gain of 10 to 15 dB in outgoing speech This equipment was developed in collaboration with M/s ITI;
- Modified STC Way Station Selector for AC Electrified Section;
- Signal Post Telephone to minimize detention of trains due to the failure of signals;
- Development of Radio Patch Circuit which has improved the efficiency of Control Communication and train punctuality in the section.

1971-1980

- Extensive development of Microwave Communication Network;
- Development of telecommunication network in AC electrified areas for train traffic control circuits;
- Implementation of Microwave Network on IR;
- Design & development of 50V, 50 Hz signalling based control circuit and way station selector and headquarter equipment for AC electrified areas;
- Talk-back and paging system for marshaling yards;
- Development of VHF and UHF Equipment.

1981-1990

In this decade the design, development & standardization activities were confined to improvement in the quality and performance of the existing equipment and system related to train traffic control circuit, long haul MW link, VHF and UHF communication and improvement in design of various RE cables and associated equipments. Major contribution in this period are:-
- Investigation of interference on telecom circuit from thyristorised electric locomotives in 25 KV AC traction area;
- Design of Solid State telecom equipment for Railway electrification;
- IIT, Chennai developed single push button selective ringing equipment for non-RE area in consultation with RDSO and it was installed at 72 stations;
- **Development of 1+4 Channel UHF equipment by M/s ECIL**: The field trial and investigation of the radio link in Secunderabad-Bhongir section of SCR was taken up. Based on the field trial, suggestions were made by RDSO to overcome the defect noticed and to incorporate it in the design of the equipment.
- Inter-Railway channel plan for MW network of IR by RDSO;
- **Development and trial of Hot Box Detector**: Indigenous development of this system was done in collaboration with M/s BEL, Ghaziabad and with the assistance of IRDE, Dehradun and has been finalized after trials. The system was based on the detection of infrared radiation emitted by hot axle box.
- **DTMF based communication system**: Initial design and development of DTMF based control equipment was started in replacement of existing 50 V, 50 Hz AC signalling with 17 impulse headquarter equipment.
- Guard-Driver VHF Communication System;
- Last Vehicle Checking Device was developed indigenously by RDSO and Bharat Electronics Ltd., Ghaziabad.
- Development of microprocessor based Self Printing Vending machine (SPT) was developed and specifications were finalized by RDSO.
- Development of Interwire Telegraph Equipment for use in RE area.

1991-2000

There have been major changes in the field of telecommunication and RDSO has also done notable work in the field of Optic Fibre Communication system, DTMF Train Traffic Control System and VHF Communication for Guard-Driver of running train as well as ASM and field staff. Circuits were modified based on the study and investigation due to introduction of DC in chopper based EMUs and thyristorised electric locos. The major contribution of RDSO in this period are:-
- **Optic Fibre Communication (OFC) System**: Design of corrugated stainless steel armoured PVC insulated Optic Fibre Cable immune to rodent was developed for use in IR. Specification No. IRS: TC 55-91 was circulated to all the Zonal Railways and based on that sources were developed.
OFC accessories like Fibre Optic Jointing Kit, OFC Cable Termination Box and Fibre Distribution Frame were developed for use with OFC cable.

- Automatic radio patching relay set for optic fibre system;
- **System Design for Fibre Optic Communication in RE Area:** Design of Optic Fibre Communication system for control and other circuits like data communication and measuring of various parameters of the OFC link were formulated and a Report No. SST-59 was circulated to Zonal Railways for adopting standard practices for OFC cable laying, jointing, termination establishment of links and maintenance.
- OFC communication link testing and measuring instrumentation;
- The directorate was closely associated with CORE, Allahabad, for installation and commissioning of OFC Link of RE and in sorting out problems encountered thereon.
- **Development of OFC based equipments:** PDH Mux, SDH equipment and other accessories required for OFC communication system were developed.
- **Development of DTMF HQ Equipment and Way Station Equipment for Control Communication:** Earlier M/s ITI, Bangalore was the source of 4 Wire VF Repeater Station and other equipment used for 50V, 50 Hz signalling system. In 1993, 2W/ 4W HQ equipment with DTMF signalling was developed for train traffic control. The newly introduced system is quite efficient and the problem of ringing has also been eliminated.
- **Development of Quad Cable and Cable based communication:** With the Railway Board policy to lay quad cable in replacement of overhead alignment, RDSO developed following equipments suitable for control working on quad cable.
  - (a) Amplifier–Equaliser System;
  - (b) Repeater equipment based on old RE practice;
  - (c) Thermo shrink joint kit for quad cable jointing.
- SMPS power plant for telecom installations to provide stable and regulated power supply.

**2001-2006**

- Satellite Imaging for Rail Navigation (SIMRAN)—A Project on Satellite Imaging for Rail Navigation has been taken up in consultation with IIT, Kanpur. The scope of the project is to collect GPS based Rail Network Mapping and Train Tracking Data and to provide wireless connectivity with running trains to display from running informations to the public through train indication boards, in the coaches and on net & IVRS.

It is envisaged to develop an effective way of monitoring every train in a certain geographical boundary for its location, speed and direction of movement. The
information so obtained can be used in a variety of ways like better controlling of trains and useful information to passenger at stations as well as moving train. Under the scope of the work each train will be equipped with GPS instrument and arrangement will be made for communication between moving train and the centralized train traffic location. The arrangement of proper hardware, software, communication media and the equipment to be provided at the Divisional Headquarters for integration is under progress. This will enable availability of real time train running information to the railways users.

- **Mobile Train Radio Communication System (GSM-R technology):** RDSO has been associated with introduction of Mobile Train Radio Communication (MTRC) system based on GSM-R technology on IR. The work of MTRC has been sanctioned on 2415 running km covering important sections of NFR, ER, EC, NCR and NR. The technology developed by M/s NORTEL and M/s Siemens have been approved on cross acceptance basis for implementation on IR.

- **Voice Data Logger/ Monitor for control circuits** has been developed as per specification No. RDSO/SPN/TC/38-2002, Revision 1.1 with Amendment No. 1. The developed equipment has several special features which were not available in the earlier version.

- **Development of L.C. gate control and monitoring system with wired and wireless data communication with private number exchange facility:** The equipment provides safe, secure and reliable means of communication between ASM and L.C. gate. It works on underground cable, overhead wires as well as wireless. The system works on local power supply as well as solar power with battery backup. It can log and store one lakh events exchanged between ASM and L.C. gate with facility to take printouts.

- **Level crossing gate telephone system as per RDSO Specification No. RDSO/SPN/TC/57/2005, Version 1** has been developed for providing safe, secure and secret communication between ASM & L.C. gate with a facility to work on underground cable as well as overhead line.

- **Emergency Socket Box made of FRP material** has been developed to specification No. RDSO/SPN/44/02 and two firms have been approved for its manufacture.
“Composite Cable (6 Copper Quad and 8/24 Fibre)

RDSO has developed Composite Cable having 6 Copper Quads and 8/24 Fibres suitable for use in non-important sections of ‘D’ & ‘E’ routes of Indian Railways. Railway Board has already issued a policy to provide this cable in such sections where separate optic fibre cable is not being laid due to cost consideration. Two firms have already been approved for manufacture of this cable and two more firms are under process for approval.”

Sri C.P. Verma is an IRSSE officer of 1973 batch. As Joint Director/Standards/Tele(T&I) in RDSO from 1984-1993, he conducted extensive field trials to study the effect of thyristor control electric locomotives and DC chopper control EMU on S&T circuits. He was also instrumental in taking measurement of audio frequency components in frequency range of 50 to 5100 Hz of the induced voltage interference due to thyristorised electric locomotive on the telecommunication circuits. Based on field trials, investigation and analysis of harmonics generated by DC chopper EMU and thyristorised electric loco (Hitachi and ABB 6000 HP) and Reports No. SST- 40A, SST- 50, SST-52, SST- 53, STT- 6 were prepared. He also studied the effect of induced EMF due to AC traction on DC track circuit in the Lab as well as in the field to corroborate the findings of M/s JARTS consultancy on the subject. Based on these studies, design of Signal and Telecommunication circuits and equipments were modified and protection measures for them are being taken by Zonal Railways.
General

Prior to 1957 RDSO was referred to as Central Standards Office for Railways (CSO) which was located at Simla, except Loco Design Wing which was at Chittaranjan. By 1964-65 all the research wings moved to Lucknow. Mechanical Design Wing (Carriage, Wagon & Loco) was headed by a Director. Mr. R.G. Da Costa was the first incumbent and he was designated as Director Mechanical Engineering (Standardisation). Later the designation got changed as Director Standards (Mechanical) and then with expansion of various design wings Loco Wing was headed by Director Standards (Motive Power). The directorate was headed by Executive Director and from December 2005 by Sr. Executive Director.

Design Software

The directorate has CAD centre with high-end workstations and latest softwares like Unigraphics for modelling & MSC Nastran for FE simulation. This group has been carrying out a large number of design activities using Computer Aided Design and Finite Element Analysis.

R&D Activities

During fifties and early sixties, the directorate was involved extensively in solving technical problems arising in manufacture of steam locos. Import substitution, fuel economy and service engineering measures like defect investigations and remedial methods were also pursued for the steam locos. Further, this Directorate has been engaged in designs and standards works related to with diesel-electric, diesel-hydraulic and electric locos since 1960s. Important accomplishments from this time, through to late 1990s, ranged from design of diesel-electric, diesel-hydraulic and electric locos, indigenisation of a large number of diesel loco components, establishment of special maintenance code in areas with reliability problems, evolving and adopting standards. The main activities of the directorate are as under:-

- Design development of diesel-electric and diesel-hydraulic locos, diesel rail cars, 700 hp diesel hydraulic multiple units, 700 hp & 1400 hp diesel electric multiple units, BG, MG & NG rail buses, 140 t diesel hydraulic breakdown cranes, re-railing equipments and rescue devices. For electric locos, design of the mechanical assemblies, bogies, under-gear, brake-gear, under-frame and superstructure is done by this directorate;
- Development and standardisation of loco systems and sub-assemblies;
- Technical investigation into operational and maintenance problems of Railways;
- Providing technical consultancy to Railway Management and other Public Sector Undertakings in matters connected with diesel traction;
- Acquisition and assimilation of state-of-the-art technology in the field of diesel locos and accident management equipments, e.g. 4000 hp loco, 140 t breakdown cranes etc;
- Indigenisation and vendor development of important critical items of diesel locos;
- Nodal directorate for issue of speed certificates for all types of rolling stocks;
- Nodal directorate for IRS/ BIS specifications.

**Important projects executed**

Major projects/ works executed by this directorate are listed below, period wise:-

1957-65
- Prototype design of WT steam loco, which was manufactured by CLW;
- Modification to convert oil fired boilers for engines in place of coal;
- Design of WCM5 DC electric loco manufactured by CLW;
- Design approval of WDM2, WDM4, YDM3, YDM4 and YDM5 locos from ALCO and GM;
- Design approval of WDS3 and ZDM2 locos of MAK Germany;
- Design approval of WDM3, WDS5 locos;
- Development of NG rail bus for Kalka-Simla section.

1965-74
- Specification for 75 t BG steam breakdown crane;
- Designed WDS3, 600 hp class shunting loco fitted with O-C-O wheel arrangement;
- WDM4 class loco of 2600 hp having bogie equipped with primary and secondary suspension; New gear set of 57:20 introduced to increase speed up to 160 km/h;
- Tender specification issued for 1500 V DC electric freight loco;
- Indigenous development of filters for rail traction diesel loco;
- Maintenance schedules prepared for diesel traction;
- Design of 1400 hp WDM6 class loco;
- Assistance to CLW to manufacture 700 hp ZDM3, ZDM4 and WDS4 locos;
- Feasibility study to upgrade 2600 hp ALCO loco to 3600 hp;
- Design and development of high speed bogie for speed potential up to 160 km/h;
- Use of dynamic independent loco brakes during emergency braking;
- Torsional vibration to study the dynamic characteristics of the crankshaft;
- Re-power packing of WDM1 class loco;
- Successful development of indigenous paper filter for lubricating oil and fuel oil;
- Design to use indigenous cylindrical journal roller bearing in WDM2 class of locos in place of imported taper roller bearing;
- Indigenous development of Suri hydro-mechanical transmission for use on WDS4 class of shunting loco;
- Design of indigenous NEI roller bearings for front bogies of YD and WL steam locos;
- Application of traction motor type TAO 659 on WDM2 loco in place of existing 165 of HE (I) L make;
- Study of providing dual cabs on diesel locos by redesigning under-frame and revising equipment lay out.

1975-84
- Alternate material was developed for cross head of WP class steam loco;
- New design of transition screw coupling for both passenger and freight locos;
- Assistance in design of YDM2 and YG class locos for export of to Tanzania;
- WCAM1 class loco designed by RDSO and built indigenously by CLW;
- Design of 4200 hp electric loco WCG2 for freight service;
• Development of dual brake, 28 LAV1 for diesel electric loco;
• Development of IRAB1 brake system for air brake stock;
• Development of electronic speed recorder;
• Design of torsional vibration damper for 700 hp MAK diesel engine;
• Optimization of tyre profile;
• Adoption of Woodward Governor on WDM2 class loco;
• Re-power packing of ZDM2, ZDM1, NDM1 class locos;
• Design and development of CO-CO flexi coil bogie for Rajdhani AC electric locos;
• Development of diesel hydraulic loco B’-B’ type for MG with Voith transmission;
• Development of an alternator rectifier system to replace the traction generator on WDM2 locos;
• Standardisation of Woodward governor in place of GE governor;
• Development of BG/MG rail car.

1985-94
• Narrow gauge battery operated loco has been developed;
• Development of high horse power electric loco with three phase drive system;
• Fabricated high speed bogie for WAP1 class loco;
• Development of computer software for calculation of emergency braking distance;
• Development of AC-DC transmission for WDM7 class loco;
• Optimization of bearing design and lubrication studies;
• Aerodynamic profile developed for short hood for WDM2 loco;
• Study of railway vehicle suspension system design with computer software to predict dynamic response of railway vehicles under different track conditions;
• Development of Locotrol;
• Development of cab simulator;
• Development of inertial engine air filtration system in place of oil bath filters;
• Application of larger thrust area turbine end bearing and radially grooved blower and bearings on 720A turbo supercharger on WDM2 locos;
• Up gradation of 2600 hp WDM2 locos to 3100 hp loco;
• Development of high capacity radiator fans.

1995-2006
• Development 4000 hp AC/AC, 3 phase diesel locomotive both for freight and passenger application;
• Design and development of 3100 hp WDP3A, WDG3A and WDM 3A locos;
• Design and development of 3300 hp WDM3D locos;
• Developed long life lube oil filters;
• Development of panel mounted brake system;
• Development of twin shield beam type halogen headlight;
• Design development of 2300 hp BG WDP1 loco;
• Development of micro controller based governor;
• Development of centrifugal lube oil cleaner;
• Design and development of standard gauge loco;
• Design and development of loco for Colombian railways;
• Design and development of bogie for cape gauge loco;
- Design and development of 2300 hp MG loco for export;
- Design and development of WDM3D loco;
- Design and development of 700 hp DEMU;
- Design and development of 1400 hp DEMU;
- Design and development of DEMU for J&K;
- Design and development of steam loco for Darjeeling Himalayan section;
- Development of microprocessor based control system;
- Development of composition brake blocks;
- Development of 350 hp MG DEMU;
- Design of 1400 hp BO-BO 16t loco for Colombia;
- Increased speed of Gottwald 140t diesel hydraulic crane from 80 km/h to 100 km/h;
- Design of diesel-electric loco with hotel load facility;
- Development of BG high speed self propelled 3-coach SPART;
- Design and development of IGBT based inverter for 4000 hp GM loco;
- Design and development of high heat capacity ‘S’ shaped wheel for BG locos;
- Development of NG loco for Darjeeling Himalayan section;
- Development of 75 t MG diesel hydraulic break down crane convertible into BG crane of equal capacity;
- Development of alternate mounted rectifier and electric driven FTMB;
- Development of self cooled rectifier for WDM3D loco;
- Development of 15 kj high capacity buffer;
- Design and development of BG loco for Sri Lanka;
- Design Development of Fabricated Bolster for WAP1/ WAP4 locos;
- Development of alternative fuel (Biodiesel);
- Improved under frame design of WDG3A loco;
- Development of streamlined cabs of WDP4 loco;
- Indigenisation of sub systems of GM locos;
- Design development of cape gauge loco bogie for Sudan;
- Development of wheel set trolley for moving locos in case of axle locking on line;
- Design Development of 17t Axle Load 2300 hp MG/Cape Gauge Loco for export to Angola;
- Design development of high adhesion bogie without equalizing mechanism for WDM3D loco.

### Salient design features of diesel rolling stocks with significant inputs by RDSO

<table>
<thead>
<tr>
<th>Loco</th>
<th>HP</th>
<th>Max. T.E. (t)</th>
<th>Year</th>
<th>Special feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>WDS3</td>
<td>618</td>
<td>17.1</td>
<td>1961</td>
<td>Mak loco. Mayback diesel engine and hydromechanical Suri transmission, O-C-O wheel arrangement.</td>
</tr>
<tr>
<td>WDS4</td>
<td>600</td>
<td>18.0</td>
<td>1969</td>
<td>Built by CLW with all features of WDS3 loco. Sri H.P.Mittal, the then JD and subsequently retired as DG/RDSO, contributed immensely in the design of the loco, which was the first diesel loco designed by RDSO.</td>
</tr>
<tr>
<td>WDM1</td>
<td>1977</td>
<td>27.90</td>
<td>1957-58</td>
<td>ALCO loco, 12 cylinder 251B engine, three axles cast steel Pennsylvania type bogies.</td>
</tr>
<tr>
<td>Locomotive Code</td>
<td>No.</td>
<td>Engine Type</td>
<td>Year</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----</td>
<td>-------------</td>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>WDM2</td>
<td>2636</td>
<td>251B engine</td>
<td>1962</td>
<td>ALCO/DLW loco, 16 cylinder 251B engine, three axles cast steel trimount bogies having single stage suspension with equalizers, coil springs and friction snubbers.</td>
</tr>
<tr>
<td>WDM3</td>
<td>2600</td>
<td></td>
<td>1967</td>
<td>Diesel hydraulic loco, 2-axle bogie, floating type centre pivot.</td>
</tr>
<tr>
<td>WDM7</td>
<td>1977</td>
<td>251B engine</td>
<td>Late 80s</td>
<td>Loco designed to replace steam locos, 12 cylinder 251B engine and three axle trimount bogies.</td>
</tr>
<tr>
<td>WDM3A</td>
<td>3100</td>
<td>251B engine</td>
<td>1994</td>
<td>DLW loco, 16 cylinder 251B engine, three axles cast steel trimount bogies having single stage suspension with equalizers, coil springs and friction snubbers.</td>
</tr>
<tr>
<td>WDS6</td>
<td>1400</td>
<td></td>
<td>1975</td>
<td>Designed for steel plants and for industrial yards, 6 cylinder 251D diesel engine, and three axle trimount bogies.</td>
</tr>
<tr>
<td>WDG3A</td>
<td>3100</td>
<td></td>
<td>1995</td>
<td>16 cylinders 251B engine, high adhesion bogie having two stage suspension, coil springs in primary and rubber spring in secondary, equalizing and compensating mechanism, unidirectional traction motors, floating type centre pivot.</td>
</tr>
<tr>
<td>WDP3A</td>
<td>3100</td>
<td></td>
<td>1998</td>
<td>16 cylinders 251B engine, two stage flexi coil bogie having helical coil springs both in primary and secondary, guide links and traction bar arrangement.</td>
</tr>
<tr>
<td>WDP1</td>
<td>2300</td>
<td></td>
<td>1995</td>
<td>Branch line loco, 12 cylinder 251B engine, two axle flexi coil fabricated bogie, floating pivot.</td>
</tr>
<tr>
<td>WDG4</td>
<td>4000</td>
<td></td>
<td>1998</td>
<td>GM AC/AC loco, 16 cylinder 2-stroke 710 GB fuel efficient diesel engine, high traction high speed three axle (HTSC) bogie, Co-Co wheel arrangement, low maintenance engine and bogie design, axle guide links, floating centre pivot.</td>
</tr>
<tr>
<td>WDP4</td>
<td>4000</td>
<td></td>
<td>1998</td>
<td>GM AC/AC loco, 16 cylinder 2-stroke 710 GB fuel efficient diesel engine, high traction high speed three axle (HTSC) bogie, A-A-1 wheel arrangement, low maintenance engine and bogie design GM loco, 16 cylinder, 2-stroke diesel engine, high traction high speed three axle (HTSC) bogie, axle guide links, floating centre pivot.</td>
</tr>
<tr>
<td>Loco</td>
<td>HP</td>
<td>Max Speed</td>
<td>Year</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------</td>
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<td>------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>YDM2 700</td>
<td>14.4</td>
<td>1986-87</td>
<td></td>
<td>MG branch line loco, B’-B’ type, Mak engine with Voith make hydraulically reversible transmission, two axle bogie having two stage suspension.</td>
</tr>
<tr>
<td>YDM4 1400</td>
<td>18.94</td>
<td>1961-62</td>
<td></td>
<td>ALCO/DLW loco, 6 cylinders 251D engine, three axles cast steel trimount bogies.</td>
</tr>
<tr>
<td>ZDM3 700</td>
<td>10.5</td>
<td>1970-71</td>
<td></td>
<td>B’-B’ type, wheel arrangement, Mak diesel engine with Suri hydro mechanical transmission.</td>
</tr>
<tr>
<td>Bangladesh Loco 2636</td>
<td>30.45</td>
<td>2001</td>
<td></td>
<td>BG loco, 16 cylinder 251B engine, three axles cast steel trimount bogies.</td>
</tr>
<tr>
<td>Malaysian Loco 2300</td>
<td>25.25</td>
<td>2002</td>
<td></td>
<td>MG loco, 12 cylinder 251B engine, Three axle fabricated flexi-coil bogie, two stage suspension having helical coil springs, floating pivot.</td>
</tr>
<tr>
<td>Vietnam Loco 1400</td>
<td>18.94</td>
<td>2003</td>
<td></td>
<td>MG loco, 6 cylinder 251D engine, three axle cast steel trimount bogies with hydraulic dampers.</td>
</tr>
<tr>
<td>Sri Lanka Loco 2300</td>
<td>24.75</td>
<td>2002</td>
<td></td>
<td>BG loco, 12 cylinder 251B engine, three axle fabricated bogie, two stage suspension with coil springs in primary and rubber springs in secondary.</td>
</tr>
<tr>
<td>Angola Loco 2300</td>
<td>30.6</td>
<td>2006</td>
<td></td>
<td>Cape Gauge loco, 12 cylinder 251B engine, three axle fabricated bogie, two stage suspension with coil springs in primary and rubber springs.</td>
</tr>
<tr>
<td>Sudan Loco (VDM4) 1350</td>
<td>18.94</td>
<td>2004</td>
<td></td>
<td>Cape Gauge loco, 6 cylinder 251D engine, three axle fabricated bogie, 915 mm wheel diameter.</td>
</tr>
<tr>
<td>MG DEMU 380</td>
<td>5.52</td>
<td>2003</td>
<td></td>
<td>Fast/frequent service, Bi-direction operation, low capital and maintenance cost.</td>
</tr>
<tr>
<td>BG DEMU 1400</td>
<td>15.2</td>
<td>2000</td>
<td></td>
<td>Fast/frequent service, Bi-direction operation, low capital maintenance cost and high acceleration.</td>
</tr>
<tr>
<td>700 hp BG DEMU 700</td>
<td>11.9</td>
<td>1994</td>
<td></td>
<td>Fast/frequent service, Bi-direction operation, low capital maintenance cost.</td>
</tr>
<tr>
<td>BG Railbus 152</td>
<td>3.9</td>
<td>2001</td>
<td></td>
<td>Self propelled, light weight, low cost, four wheeler &amp; Bi-direction.</td>
</tr>
<tr>
<td>MG Railbus 120</td>
<td>1.76</td>
<td>1998</td>
<td></td>
<td>Self propelled, light weight, low cost, four wheeler &amp; Bi-direction.</td>
</tr>
<tr>
<td>Telescopic Crane 285</td>
<td>12</td>
<td>2006-07</td>
<td></td>
<td>Telescopic boom, can work under long tunnel including metros and OHE without infringement (Under development).</td>
</tr>
<tr>
<td>140 t Crane 285</td>
<td>12</td>
<td>1986</td>
<td></td>
<td>Three axle bogie with coil &amp; disc spring with ‘A’ frame.</td>
</tr>
</tbody>
</table>
Photographs of the some important rolling stock wherein considerable design inputs have been given by this Directorate are given below:

- Shunting loco, 650 hp
- WDM3 loco, 2600 hp (1967)
- WDM3A loco, 3100 hp (1994)
- WDS6 loco, 1400 hp (1975)
- WDP3A loco, 3100 hp (1998)
- WDG4 loco, 4000 hp (1998)
WDP4 loco, 4000 hp (1998)

ZDM3 loco, 700 hp (1970-71)

YDM4 loco, 1400 hp (1961-62)

Malaysian loco (Export), 2300 hp (2002)

Vietnam loco (Export), 1400 hp (2003)

700 hp BG DEMU, 700 hp (1994)
BG Railbus, 152 hp (2001)  
BG DEMU, 1400 hp (2000)  

Telescopic Crane, 285 hp (Under development)  

140 t Crane, 285 hp (1986)
Codes, Manuals and Specifications

Motive Power Directorate is the nodal Directorate for all IRS/ BIS specifications. It has contributed significantly to most of the specifications for diesel electric locos, DMU’s, rail buses, cranes and their components and has issued several manuals and specifications.

Sri M.M. Suri while working in RDSO developed hydraulic transmission with hydraulic converter and mechanical clutch, named as Suri-Transmission. The development of Suri-Transmission and the 650 hp loco was completed during the year along with M/s Maschinenbau Kiel Aktiengesellschaft, West Germany. The first 650 hp diesel loco, fitted with this transmission went into operation in Germany in January 1961. Suri-Transmission was introduced in WDS3 in 1965 in Germany, which was imported by IR. Subsequently these locos were manufactured with Suri-Transmission at CLW. Sri M.M. Suri was the first man in RDSO to have been honoured with the award of Padmashri by the President of India.
General

The directorate is working under Executive Director from the year 1992. Earlier it was headed by Director/Additional Director since 1986. The Engine Development Directorate was inaugurated by the then Honorable Minister for Railways Late Sri Madhava Rao Scindia on 4.4.1987.

Test Bed and R&D facilities

The R&D facilities have been designed by RDSO engineers. The best features from a number of Diesel Engine Research Institutes in the world have been picked up and adapted to suit conditions for IR. The only other facility comparable in Asia is in China Academy of Railway Sciences.

The basic facility comprises of four engine test beds, each housed in a separate soundproof test cell. The test bed has its own control cabin, isolated from the test cell with a glass intervening partition for visible monitoring during tests. The test cells are equipped with precision and sophisticated dynamometers for loading the engine and evaluation starting from 400 kW to 6000 kW. The test beds have their own microprocessor controlled data acquisition and control systems and VDU display of readings of pressures, temperatures and other parameters. There are about 80 transducers and sensors in each test cell conveying information on different parameters of the test engines to the microprocessor based test commander for further processing with the help of sophisticated software. An electric over-head crane of 30 t capacity handles the test engines/dynamometers through removable test cell roofs. Special purpose instrumentation includes High Speed Data Acquisition System, Blow-By and Smoke Meters, Fuel and Lube Oil Consumption Measurement equipment, etc. Provision for measuring Air Flow into engine at simulated temperature conditions is available.

These test beds have also been
provided with High Speed Data Acquisition System having the capability to acquire data from the engine at the frequency of 100 MHz. 16 channels of analog data can be accessed simultaneously from various transducers such as Cylinder pressure, Valve lift, Fuel injection pressure, Injector needle valve lift etc. This system has the capability to acquire data from the engine at the rate of 0.1 degree of the crank shaft rotation. This equipment is useful for acquiring the P-q diagram of the engine and conducting heat release studies.

Apart from the testing facilities as explained above, the directorate is also equipped with the following ancillary facilities:

- CAD centre with the state of art high-end workstations and latest softwares like Mechanical Desktop for modelling & MSC Nastran for finite element simulation;
- Metrology Laboratory for measurement and inspection of dimensions;
- Instrumentation Laboratory for calibration and maintenance of electronic equipment;
- Stress Analysis Laboratory with facilities for model testing with polariscope;
- Fuel Injection Laboratory for testing and calibration of equipment;
- Prototype workshop for modification of components and manufacture of jigs and fixtures;
- Water treatment plant for softening of dynamometer water and treatment of engine water.

R&D Activities

Indian Railways consume approximately two billion liters of diesel fuel annually through its fleet of 4000 Freight & Passenger diesel electric locos consisting of medium speed 16-cylinder, 12-cylinder and 6-cylinder ALCO engines. The high-energy costs, world over, have forced the engine manufacturers to substantially improve and optimize the performance and control of the engine. Keeping in view these facts, R&D projects have been taken up to optimize the design so as to reduce the fuel consumption by improvement in energy efficiency of ALCO locos in the following four stages:

**STAGE-I**

During early nineties, fuel-efficient kit for original 16-cylinder DLW manufactured ALCO engines was developed, which reduced specific fuel consumption by more than 6% and lube oil consumption by about 15%. The reduction in fuel consumption at full load was from 166 gm/bhp-hr to 156 gm/bhp-hr at full load. Similarly, there was reduction in the lube-fuel oil ratio from 1.5% to 1.27%. The major modifications in the design are as under:

- **Development of Efficient After-Cooler:** After-cooler in a turbocharged engine cools the compressed air to engine, thereby increasing the density of charge air. A large after-cooler with higher effectiveness was designed for better cooling of compressed air. The size of the core was increased to get higher contact area between water and air. The new after cooler, called Large After-cooler, also resulted in lower cycle temperatures and lower thermal stresses on the engine. This modification increased cooling effectiveness of after cooler from 50% to 75% and decreased exhaust gas temperature from 600°C to 520°C resulting in improved fuel efficiency.
• **Development of Improved Turbochargers:** The original DLW manufactured locos were fitted with ALCO A720 turbochargers. These turbochargers were replaced by fuel-efficient Napier NA295 A720 and ABB VTC-304 VG-13 turbochargers.

• **Modification in Cooling Water Piping:** The cooling water piping arrangement of the loco was modified for better cooling of charge air.

• **Development of 12.5 Compression Ratio Steel Cap Pistons:** Original ALCO engines had aluminium dish top pistons. Use of high efficiency turbochargers and higher capacity fuel injection pumps, led to higher peak firing pressures. As aluminium pistons cannot withstand these higher firing pressures, steel cap pistons were developed. These steel cap pistons were provided with special crown profile for better combustion. Steel cap pistons have additional advantages of longer life due to lesser wear of ring grooves and ability to withstand higher thermal load due to better cooling.

• **Modification of Fuel Injection Pump:** The original fuel injection pumps used on ALCO Engines had plunger diameter of 15 mm. The plunger diameter of the fuel injection pump was increased from 15 mm to 17 mm. This modification led to sharper fuel injection i.e. injection at higher-pressure. The modification resulted in increase of peak fuel line pressure from 750 to 850 bars and, thus, improvement in the fuel efficiency.

• **Modification of Cam Shaft:** Camshaft with increased overlap of 140 degree in place of 123 degree was designed to improve scavenging. The exhaust and inlet air cam lobes were modified so that both the inlet and exhaust valves are kept open for longer period. With this modification, pressurised inlet air was able to force out the burnt gases for longer period. This improved quality of charge air had significant effect on fuel efficiency of the engine.

**STAGE-II**

Fuel-efficient 2600 hp ALCO Engine was upgraded to 3100 hp by increasing the engine rpm from 1000 to 1050 rpm and introducing high efficiency turbocharger in the year 1992. Apart from upgradation, the above changes further resulted in the reduction in fuel consumption from 156 gm/ bhp-hr to 153 gm/ bhp-hr at 8th notch and reduction in the lube-fuel oil ratio from 1.27% to 1.12%. The major modifications in this stage are as under:-

• **Development of High Efficiency Turbo Chargers:** The High Efficiency Turbochargers available in world market were tested and optimised on 3100 hp upgraded engine. Two new designs of turbochargers, ABB VTC-304 VG-15 and GE 7S1716 (Twin discharge) were introduced for 3100 HP engine. There was increase in the Booster pressure with the use of above turbos from 1.6 to 1.9 bars. The speed of rotor at rated power also increased to 27000 rpm against 23000 rpm of Stage-I turbochargers.

![GE 7S1716 Twin Discharge Turbo](image-url)
A comparison between the turbochargers used in the two stages is given below:-

<table>
<thead>
<tr>
<th>Stages</th>
<th>Stage-I</th>
<th>Stage-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology-wise classification of turbochargers</td>
<td>Efficient</td>
<td>High efficiency</td>
</tr>
<tr>
<td>Turbo models used by RDSO</td>
<td>Napier NA295 IR ABB VTC-304 VG-13</td>
<td>GE 7S1716 ABB VTC-304 VG-15</td>
</tr>
<tr>
<td>Turbo over all efficiency</td>
<td>60%</td>
<td>64%</td>
</tr>
<tr>
<td>Exhaust gas temp.</td>
<td>580°C</td>
<td>500°C</td>
</tr>
<tr>
<td>Frequency of maintenance</td>
<td>2 Years</td>
<td>4 years</td>
</tr>
<tr>
<td>Salient features</td>
<td>Bearing sliding fit. Floating bush. Thrust on cold side</td>
<td>Bearing sliding fit. Thrust on both sides</td>
</tr>
</tbody>
</table>

- **Introduction of Fuel Efficient Piston Rings:** DLW engines conventionally employed a piston ring set of 5-rings having square taper, oil conformable and oil scraper configuration. Trial with piston ring set of barrel taper oil conformable and oil conformable configuration showed considerable reduction in fuel and lube oil consumption. The ring set has been named as fuel-efficient ring set.

- **Use of Multigrade Lubricating Oil:** Single Grade SAE40 lubricating oils, as recommended originally by ALCO, were being used by IR, up to 1998. Development of 20W40 multigrade oil was taken up by RDSO from 1995 onwards. These oils have an additional additive called Viscosity Index Improver (VII) to reduce the change in viscosity with change in temperature. The mono-grade lube oil has a problem that its lubricating property deteriorates at higher operating temperature. The lubrication of moving components was found to be better at higher temperatures with multigrade lubricating oil. This behaviour of multigrade oils improves the lubrication properties at working temperatures and also results in savings of fuel. Based on results of extensive field trials of performance of multigrade oils as compared to mono-grade oils, IR switched over to use of Multigrade oil.

**STAGE-III**

During this stage, 3100 hp ALCO Engines have been upgraded to 3300 hp in the year 2001 and to 3600 hp in 2002. The fuel consumption of the upgraded ALCO engines further reduced from 153 gm/bhp-hr to 150 gm/bhp-hr on top notch. Similarly, there was reduction in the lube-fuel oil ratio from 1.12% to 1%. The major modifications in this stage are as under:-

- **Introduction of New Generation Turbochargers:** New generation air-cooled turbochargers having global efficiency of 70% were introduced in place of High Efficiency Turbochargers. Two New Generation Turbochargers, ABB TPR-61 & HS 5800 NGT were optimised on RDSO’s Test Bed for 3300 hp and 3600 hp engines and a broadband matching was established. The booster air pressures on 3300 hp and

![ABB TPR-61 Turbo](image1)

![HS 5800 NGT](image2)
3600 hp were found as 2.0 and 2.2 bars respectively. The rotor speed of these turbochargers went up to 30,000 rpm on 3600 hp engines.

- **Development of Stiffer Unit Cam Shaft:** For generation of higher horsepower with improved fuel efficiency, fuel cam lobe design needed change for still sharper fuel injection. A new design of camshaft with modified profile of fuel cam lobe was developed. This design was called Stiffer Unit Camshaft. Peak fuel line pressure of 1100 bars was achieved with this camshaft.

- **Development of Plus cylinder head:** To take care of increased heat load, plus cylinder heads have been developed having air intake valve angle of 30 degree instead of 45 degree in the conventional cylinder head. The intake and exhaust ports have been streamlined for improved air flow minimize flow resistance and improve breathing of cylinder head. Casting quality such as fillet radii and internal surface finish has been improved. The heat transfer rate in the new design has also been enhanced due to thinner flame deck; low gap between the flame deck and the middle deck; and the machined valve bridges. The location of cooling passages has also been changed to give better heat transfer. The valve seat inserts have been press fitted without snap ring, resulting in larger contact area and thus better heat transfer.

**Changes in engine configuration and operating parameters**

The activities mentioned above have resulted in the following optimum configuration of 16-cylinder ALCO diesel engine with 3600 hp:-

- Stiffer Unit Cam Shaft assembly (22° BTDC start of injection);
- GE 7S1716 turbocharger (26 inch² nozzle) with twin discharge;
- 11.75 Compression ratio Super Bowl steel cap pistons;
- Plus cylinder head assembly;
- High pressure fuel tube for 1200 bar pressure rating;
- 17 mm FIP having fuel rack of 35 divisions;
- Rest of the engine components remain same as existing 3100 hp.

The above 16 Cylinder DLW/ ALCO test engine upgraded to 3600 hp rating has also qualified the 100 hour performance test as per codal requirements of UIC623.2/KTA3702.2.

**STAGE-IV**

This stage consists of the technological improvements, where fuel saving on the loco engines has been achieved on the test bed but yet to be implemented in the field. Fuel and lube oil consumption of DLW manufactured ALCO engines have been further reduced by more than 2% and 6% with these modifications.

- **Electronic Fuel Injection System:** Mechanical fuel injection pumps, which were being used on ALCO Engines, had no provision of changing start of injection at various notches. Since Diesel Engine consumes maximum fuel at 7th and 8th notches, the fuel injection timing on this engine are optimised to give lowest specific fuel consumption at these notches.
Electronic fuel injection pump has the advantage of setting the start and end of injection for each cylinder individually, which results in injection of optimum quantity of fuel in combustion chamber at right moment.

Electronic fuel injection system also eliminates a number of mechanical engine components, the most prominent being the Governor itself, thereby reducing maintenance effort and resulting in higher reliability.

Other advantages of the system include elimination of hot engine alarms; better control and diagnostics; design flexibility; automatic balancing; and lesser exhaust emissions.

The Electronic Fuel Injection System developed by RDSO has been optimised for ALCO Engine at RDSO’s Test Bed.

**Double Helix Fuel Injection Pump:**
RDSO has also developed double helix pumps for ALCO Engine. In double helix design, helix is provided on the top and bottom edges (both) of FIP plunger, so that opening of spill port is also optimized and controlled resulting in the optimization of start of injection at part load as well.

The helix has been manufactured as a linear approximation of results obtained on Electronic Fuel Injection System.

**Other R&D Activities:**

- **Reduction of Emissions from ALCO Loco Engines:** United States of America (USA) has done the maximum work in the world in the field of measurements, control and legislation for the emissions from Diesel locos. In Europe, although European Rail Road Institute has done the work to finalise emission testing procedures and testing cycles for emissions from diesel locos, there is at present no legislation in India to regulate loco emissions. Europe had been a bit slow in laying emission norms for Diesel locos since diesel traction in Europe accounts for only about 15% of total Railway transport volume against 80% volume of Railway transport by Diesels in USA (virtually 100% in case of freight).

  Since NO\textsubscript{x} emissions are most problematic for diesel engines, the first effort made by RDSO in November 1996 was to measure only the NO\textsubscript{x} emissions. The measurements were made on the fuel-efficient 6-cylinder engine on RDSO engine test bed using the Thermo-Electric make equipment (based on Chemiluminescent detector principle). The measurements and calculations gave the NO\textsubscript{x} value of 11.09 gm/kW-hr. For the measurements on 12 and 16 Cylinder Engine, portable emission measuring equipment was used in November 2000.

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**Instrumented 16 Cylinder Engine**

The portable equipment are not capable of measuring particulates, therefore, only gaseous emission measurements were carried out. Emission measurements were made with different engine configurations. It has been seen that the ALCO loco engine
Emissions, as measured with Portable Emission measuring equipment, are inferior in respect of CO and NOx. Since HC values in the ALCO engines are much lower than the limits laid in EPA Tier-2 standards, it should not be difficult to achieve the specified limits of CO and NOx.

Even though there is presently no legislation in the country for limiting the emissions from loco, RDSO has set the following action plan to measure the emissions and reduce them to the limits laid down in International Standards:

(a) The dedicated Mass emission measuring equipment capable of measurements as per International Standards have recently been commissioned on the test beds of Engine Development Directorate of RDSO. The work of measurement of emissions as per International Standards followed by their reduction to the levels specified in EPA and UIC is presently in hand.

(b) Since change in the design of engine components and improvement in the fuel and lube oil specifications can contribute in reduction of emissions, discussions have been held with most of the suppliers of major engine components as well as fuel/lube oil and they all have agreed to associate with RDSO and provide technical support so as to achieve the objective of meeting International Emission standards. A consultancy contract is also likely to be awarded to a leading engine designer firm in the World to assist RDSO in reducing the emissions of their locos.

(c) In the second phase, IR plans to set up emission measurement car for measurement of in-use emissions at the load box facility of Diesel Sheds/ Workshops in the country.

- **GM EMD 710 G3B 4000 hp Diesel Engine Testing Facilities:** Engine Development Directorate has undertaken the setting-up of GM EMD 710 G3 diesel engine test bed for research and design development purposes and to assist in manufacturing and operation of GM locos on IR.

During year 2003-04, there was no facility of testing of DLW assembled GM Engines at DLW, Varanasi. Hence, a decision was taken by Railway Board to test the DLW assembled GM Engine on the test bed facilities of ED Directorate.

A total of 42 such engines were tested by this Directorate by April 2005 till the testing facilities for this Engine were created at DLW. Credit of Rs. 1.19 crores (@2.85 lacs per engine) was received from DLW for testing of 42 GM engines.

- **Research on Bio Diesel:** With a view to reduce the environmental impact of fuel, use of Bio-diesel as an alternate fuel for traction purposes has been investigated by RDSO. Full-scale laboratory testing on a 16-cylinder medium-speed engine on the engine test bed has been conducted followed by field trials on diesel loco hauled trains. The following observations have been made during the trials:
  - No significant power loss is observed for various bio-diesel blends including B100, i.e. pure bio-diesel.
  - The specific fuel consumption (bsfc), is higher with higher blends of bio-diesel, although at lower notches the bsfc is similar or better than petro-diesel (B00).
- With bio-diesel blends, the exhaust gas temperatures have shown a downward trend.
- The boost air pressures have also continually reduced with increasing percentage of bio-diesel in the blends.
- Gaseous hydrocarbons in general show a downward trend with increasing bio-diesel percentage except for B50.

Other action taken to promote the use of Bio-Diesel in IR is as under:
- SR and SER have got their own transesterification plant and are running few trains with B10 diesel.
- All the Railways are growing Jatropha plants on their surplus land.

- IR have signed an MOU with Indian Oil Corporation to plant Jatropha saplings on land to be provided by IR. This pilot project is aimed at generating the base-line scientific data on growth of plants, seeding, yield of the oil seeds, oil from seeds etc.

**Main Achievements**

As a result of the investigations and research done by the Engine Development Directorate, the following main achievements leading to substantial economy in fuel consumption and lubrication oil consumption along with improved reliability and efficiency with higher horse power have been obtained:-

<table>
<thead>
<tr>
<th>Achievements</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction in Specific fuel consumption of ALCO 16-cylinder engine from 166 to 152 gm/bhp-hr at full load, 20% reduction in lube oil consumption and reduction in exhaust gas temperature by 100°C. Reduction in Specific fuel consumption of ALCO 12-cylinder engine from 168 to 155 gm/bhp-hr at full load, 20% reduction in lube oil consumption and reduction in exhaust gas temperature by 80°C. Reduction in Specific fuel consumption of ALCO 6-cylinder engine from 182 to 168 gm/bhp-hr at full load, 20% reduction in lube oil consumption and reduction in exhaust gas temperature by 90°C.</td>
<td>Reduction in fuel consumption by 14 gm/bhp-hr at full load results in saving of Rs. 20 lacs per loco per year. Reduction in fuel consumption by 13 gm/bhp-hr at full load results in saving of Rs. 14 lacs per loco per year. Reduction in fuel consumption by 14 gm/bhp-hr at full load results in saving of Rs. 7.5 lacs per loco per year.</td>
</tr>
</tbody>
</table>
| Power uprating of 16 cylinder engine  
  Ø Stage I - 2600 to 3100 hp  
  Ø Stage II - 3100 to 3300 hp  
  Ø Stage III - 3300 to 3600 hp | One time saving of Rs. 10 crores for every stage due to development of Swadeshi Technology, which otherwise would have to be imported. |
| Power uprating of 12 cylinder engine from 1950 hp to 2300 hp | Cost reduction of Rs. 20,000 on each piston. Total saving of Rs. 6 crores per year for IR annual requirement of such pistons as 3000. |
| Development of Swadeshi Steel Cap Pistons | Due to cost reduction of Rs. 5 lacs on each Turbocharger, a saving of Rs. 12.50 crores per year on the requirement of 250 turbochargers per year |
| Indigenisation of Turbochargers | |
**Important Projects Completed:**

- Creation of testing facilities for 4000 hp GM-EMD 710 G3B diesel engines. So far 42 DLW manufactured GM-EMD engines have been tested. Ten indigenized components of GM-EMD engine have also been tested.
- Development of fuel-efficient kit for 6 cylinder 251-D engines;
- Optimization of combustion chamber profile;
- Strengthening of 16-cylinder engine block;
- Development and optimization of Electronic fuel injection system for 12 and 16 cylinder Diesel Engines;
- Development of double helix fuel injection pump for 12 and 16 cylinder Diesel Engines;
- Optimization of various types of injector nozzles for 12 and 16 cylinder DLW engines;
- Development of Stiffer unit camshaft including its FEM analysis;
- Development and performance monitoring of new generation turbochargers;
- Development of 3-entry casing for ABB TPR-61 high efficiency turbocharger;
- Development of high capacity Plate type lube oil cooler;
- Development of 16-row large after cooler core;
- Development of all-aluminium after cooler core of 98% cooling efficiency;
- Development of single bolt design steel cap pistons;
- Design improvement of Goetze make steel cap pistons to reduce lube oil consumption;
- Development of interchangeable 11.75 CR 23.2 kg steel cap pistons from alternate indigenous sources;
- Streamlined lube oil piping circuit for WDM2 / WDG2 / WDP1 locos;
- Development of improved water piping circuit for DLW locos;
- Design of microprocessor based fuel consumption measuring equipment.

**Main Projects in Hand:**

- Measurement and reduction of emissions of diesel locos of IR as per international standards;
- **Power Upgradation of 12-Cylinder Diesel Engine:** The horsepower of existing 12-cylinder engine is 2300 hp. Most of the export enquiries being received by DLW are for 2300-2600 hp with stringent axle load requirement. To meet axle load limits, use of 16-cylinder engine imposes restriction on the maximum length of loco. This makes the loco congested and maintenance unfriendly. Use of 12-cylinder engine with upgraded horse power will reduce the engine length by one meter and reduce weight by about 4.5 t. The above reduction in weight will result in reduction of axle load, thereby enabling IR to compete in International market. In view of above, 12-cylinder, 2300 hp engine is now proposed to be uprated and tested up to 3000 hp for export potential. This is in line with the upgradation of 16-cylinder 251 engines to 3600 hp. Upgradation of 12-cylinder diesel engine from 2300 hp to 3000 hp results in reduction in cost per unit of hp about 21.87%.
- **Reduction in Specific Fuel Consumption of 6-Cylinder Diesel Engines:** Presently, 832 nos. of 6-cylinder YDM₄ & WDS₅ locos are working in IR. Any improvement in SFC will result in considerable fuel savings. RDSO has the experience to reduce fuel consumption in
case of 16 & 12-cylinder diesel engines. However, not much work has been done on 6-cylinder engines. Therefore, the work of improvement in fuel efficiency of 6-cylinder will result in considerable fuel saving.

- Development of coupled diesel engine for 6000 hp DG set application;
- Improvement in ‘Cylinder Liner-Piston’ Interface of ALCO Engine;
- Optimization of ALCO diesel engines with bio-diesel as fuel;
- Optimization of electronic fuel injection system for 3100 hp ALCO diesel engine fitted with Stiffer Unit Camshaft;
- Development of electronic fuel injection system for 3300/ 3600 hp ALCO diesel engine;
- Increase in the horse power of EMD engine up to 4500 hp;
- Development of alternative sources for unit injectors of GM diesel engine;
- Measurement of lube oil consumption in the field using Barium Tracer Technique;
- Development & testing of preventive exhaust grid for DLW manufactured ALCO 251B engine;
- Development of 3-Entry gas inlet casing for ABB TPR-61 turbocharger;
- Testing of large after-cooler cores of new design;
- Development of alternative sources of plate type lube oil coolers;
- Development and testing of ejector assembly in place of crank case exhauster in ALCO engines;
- Testing of fuel additives/ saving devices;
- Performance monitoring of various makes of 11.75 CR steel cap pistons.

**Test reports, Specifications and Technical Papers**

The directorate has prepared approximately 200 test reports/ technical specifications along with a larger number of technical papers.

*Sri A. Chakravorty, the then Director/Engine Development, who was motivated by his own driving spirit had played a very important role in setting-up world class diesel engine research facilities with his team and has contributed significantly in bringing about improvements to reduce fuel consumption in ALCO locomotive variants along with his team. These improvements have resulted in saving of fuel costing hundreds of crores of rupees. He subsequently retired as Additional Director General, RDSO.*
Carriage Directorate

General

Executive Director Standards (Carriage) heads the Carriage Directorate since July 1995 which was earlier Director Standards (Carriage). The directorate has been bringing about improvements in coaches for safety, passenger comfort, increased capacity and higher speeds. It is having a computer lab equipped with high power server and workstations for carrying out engineering analysis on which a number of designs have been evolved using finite element analysis, vehicle dynamics simulations and crashworthy design simulations.

R&D Activities

Two of the important activities which have been used on IR, one for improvement of coaches for Rajdhani Express and the other for crashworthy design of coaches are briefly mentioned below:-

Rajdhani Express

For introduction of first Rajdhani Express, some modifications in ICF coaches were done so as to increase the speed without adversely affecting safety or comfort and oscillation trials were carried out for speeds up to 140 km/h. In seventies, Railway Board asked RDSO to examine feasibility of fitting air brake on passenger stock. Based on detailed study and trial, air brakes were first fitted on Mumbai-Delhi Rajdhani Express and it went into commercial service in June, 1982 on IR.

Crashworthy Designs of ICF Coaches

The activity of crashworthy design of coaches was taken-up in August 2003 and completed in December 2006. The objectives of the design is to minimize deformation in passenger occupied area in case of an accident and to prevent climbing of coaches over one another. This is done by energy absorption in non-passenger area through controlled collapse.

The design has been done by finite element computer model of the coach and simulating the model on the computer. Then prototype was manufactured and was tested for its crashworthiness and design has been finalized.

A Ramp-Platen crash test was conducted on 29.03.05 with a GS coach. The test results were encouraging. Subsequently, one rake of crashworthy design coaches was manufactured by RCF in February 2006 which has since then been in service on Barauni-Amritsar section in Jan-Seva Express. The second series of crash tests involving two sets, one with only a GS coach and the second with coupled GS & SLR coaches were carried out on 17th and 21st of February 2006 at Alam Nagar station near Lucknow. Crashworthy designs for ICF coach variants including Sleeper and AC coaches have been finalized and key drawings have been issued to production units.

Crash Test conducted on 17th Feb 2006
Crash Test conducted on 21st Feb 2006

R&D Activities completed

The major R&D activities bringing about significant improvements in the design of coaching stock for increasing speeds, safety and better riding comfort, are listed below:

<table>
<thead>
<tr>
<th>Decade</th>
<th>Major Activities</th>
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<tbody>
<tr>
<td>1957 to 1966</td>
<td>• Development of all coil suspension for coaches;</td>
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<tr>
<td></td>
<td>• Introduction of A. C. Chair Car coach.</td>
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<tr>
<td>1967 to 1976</td>
<td>• Introduction of Rajdhani Express;</td>
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<tr>
<td></td>
<td>• Development of AC 2-tier Coach;</td>
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<tr>
<td></td>
<td>• Introduction of Composition brake blocks in EMU services.</td>
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<tr>
<td>1977 to 1986</td>
<td>• Development of non-AC double-decker;</td>
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<td></td>
<td>• Introduction of air brakes on coaching stock;</td>
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<tr>
<td></td>
<td>• Development of MG AC 2-tier;</td>
</tr>
<tr>
<td></td>
<td>• Introduction of Shatabdi Express.</td>
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<tr>
<td>1987 to 1996</td>
<td>• Development of AC 3-tier coach;</td>
</tr>
<tr>
<td></td>
<td>• Development of IRY coach on IR-20 bogie;</td>
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<tr>
<td></td>
<td>• Development and introduction of UIC vestibules;</td>
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<tr>
<td></td>
<td>• Development of DMUs.</td>
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<tr>
<td>1997 to 2006</td>
<td>• Introduction of air springs on suburban stock;</td>
</tr>
<tr>
<td></td>
<td>• Development of container flats;</td>
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<tr>
<td></td>
<td>• Introduction of Alstom coaches and development of its variants;</td>
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<tr>
<td></td>
<td>• Development of FRP modular toilets;</td>
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<tr>
<td></td>
<td>• Introduction of CBCs on coaching stock;</td>
</tr>
<tr>
<td></td>
<td>• Development of Bogie mounted brake cylinders;</td>
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<tr>
<td></td>
<td>• Development of Solid wheels;</td>
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<tr>
<td></td>
<td>• Introduction of controlled discharged toilet system;</td>
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<tr>
<td></td>
<td>• Introduction of PU painting of coaches;</td>
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<tr>
<td></td>
<td>• Development of aerodynamic profile and electro-pneumatic brakes for DEMUs;</td>
</tr>
<tr>
<td></td>
<td>• Development of fire retardant furnishing materials;</td>
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<tr>
<td></td>
<td>• Development of mobile bridge inspection unit;</td>
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<td></td>
<td>• Development of self propelled ultrasonic rail test car;</td>
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<tr>
<td></td>
<td>• Development of high capacity parcel van;</td>
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<tr>
<td></td>
<td>• Development of coaches for disabled passengers;</td>
</tr>
<tr>
<td></td>
<td>• Development of crashworthy coaches.</td>
</tr>
</tbody>
</table>

Quality objectives

The quality objectives concerning safety, asset reliability, environment and passenger comfort/ faster travel are as follows: -
**Safety:**

- Development of crashworthy design of coaches for enhanced safety of passengers by suitably changing the design so that the coach progressively collapse from the end rather than collapse in passenger area. Also reducing impact force at the time of collapse from existing 8.5 MN to 4 MN at the time of collapse.
- Development of High Speed Self Propelled Accident Relief Train for faster travel to accident site at speed of 105 km/h on mainline track and 115 km/h on Rajdhani track.
- Upgrading specifications of the materials used in coach interiors for improving fire safety to UIC norms by introducing the following:
  - Flammability – Resistance to spread of flame with the value class B or better, when tested as per UIC– 564-2 OR;
  - Deterioration of visibility of smoke – Class B or better when tested as per Appendix –15 of UIC – 564-2 OR;
  - Limiting Oxygen Index – Minimum 28 when tested as per IS: 13501;
  - Toxicity – Less than 1 when tested as per NCD –1409.
  - Setting up of fire test lab;
- Development of crash worthy design of LHB coaches.

**Asset reliability**

Fitment of Vertical Shock Absorber in primary suspension in lieu of conventional dashpot.

**Environment**

Modification in Toilet Discharge System in coaches to prevent rail corrosion.

**Passenger Comfort/ Faster Travel:**

- Design and development of air spring for ICF main line Rajdhani coaches to improve ride index from 3.5 to 3.25 to make journey more comfortable for the passengers;
- Air suspension for suburban coaching stock: To improve the riding and reduce maintenance requirements enhanced capacity (180 KN vertical load) air spring has been designed for suburban coaching stock (EMU/ DMU). These shall provide ride comfort within a ride index of 3.5 to the traveling public (acceptable limit 4.0).
- Develop failure indication system to give audio-visual signal to driver in case of deflation of air spring;
- To develop tight lock CBC couplers with anti-climbing features in coaches;
- To develop new modern classical design with air brakes, roller bearings and hand brakes for NG coaches;
- To develop new modern tourist NG coach with panoramic layout air brakes, roller bearing and hand brakes for mountain railways;
- To develop soft side buffers for CBC equipped coaches;
- Standardization and upgradation of NG bogie for 762 mm and 610 mm gauges;
- Arrangement for keeping water at normal temperature in passenger coaches in summers and winters;
- Development of air springs for LHB stock.
Wagon Directorate

General

The directorate is working under Executive Director/ Sr. Executive Director from 1995 which was earlier headed by Director Standards (Mechanical) since 1968. Prior to 1968, it was looked after by Joint Director under Director Standards (Mechanical).

R&D Activities

During pre-independence period, British firms M/s Rendel, Palmer and Tritton were providing design and development of freight stocks for IR. At that time nearly all the wagons were having low carrying capacity and low payload to tare weight ratio in the range of 1.09 to 2.64. Majority of the wagons were 4-wheelers and were fitted with plain bearings, vacuum brake system and screw couplings. The reliability of the stock was low along with high ineffective and extensive maintenance requirements.

BOX Wagon

The first major design development undertaken by RDSO in 1957-58 was for BG system and bogie type open BOX wagon was designed and developed for bulk movement of coal. This wagon with 25 t tare weight and has carrying capacity of 55 t but was working on vacuum brakes and fabricated bogies of steel plates. Presently, about 14,000 wagons are in use on IR. BOXT, BOBR and BOXE are BOX wagons with transition, screw and Centre Buffer Couplers (CBC) respectively and were introduced in sixties. In 1960, BOX wagon was designed with the provision of UIC bogie, roller bearings and center buffer couplers but the wagon was continuing with vacuum brake system and bogies were fabricated out of steel plates.

BOXN Wagon

During 1980, a new high sided wagon named BOXN was introduced with air brake system, sealed type cartridge taper roller bearing and cast steel ‘CASNUB’ bogie. The wagon was also provided with high capacity draft gear and high tensile center buffer coupler. These designs were adopted based on then prevalent contemporary advances made in developed countries. The advantages of BOXN wagon over BOX wagon are apparent from the following table:-

<table>
<thead>
<tr>
<th>Feature</th>
<th>BOX</th>
<th>BOXN</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tare</td>
<td>25 t</td>
<td>23.2 t</td>
<td>Less by 7.2%</td>
</tr>
<tr>
<td>Payload</td>
<td>56.28 t</td>
<td>58.08 t</td>
<td>More by 3%</td>
</tr>
<tr>
<td>Pay to tare ratio</td>
<td>2.25</td>
<td>2.50</td>
<td>Higher by 11%</td>
</tr>
<tr>
<td>Throughput per rake</td>
<td>2588 t</td>
<td>3368 t</td>
<td>Higher by 30%</td>
</tr>
</tbody>
</table>
Some of the additional inputs given in the design of BOXN wagon were as follows:-

- **Provision of Pneumatic brakes:** With higher gross trailing load of over 4000 t, provision of Pneumatic brakes in the wagons was necessary so as to keep the emergency braking distance within 1000 m, catered for under the existing signalling system.

- **Provision of Casnub bogies with cartridge taper roller bearings:** Casnub bogies were selected over fabricated bogies and the casting bogies due to many inherent advantages namely lighter weight, shorter length, simplified maintenance and built in reserve capacity. The Casnub bogie also showed better riding characteristics.

- **Body construction:** The length of BOXN wagon was reduced to 10.713 m from 13.729 m as in BOX wagon. This allowed 58 BOXN wagons as against 46 BOX wagons per rake for the same length of the train. This gave a track loading density of 7.59 t/m as against 5.92 t/m for a BOX wagon, which was the maximum loading permissible as per IRS BGML loading.

With these inputs, the BOXN wagon became the workhorse of IR for transporting the main commodities viz. coal, iron ore and many other consignments which can be loaded in open wagons and about 76,000 BOXN wagon are in use on IR. Sri T.N.Tandon, the then Director (Wagon) was instrumental in evolution of the design of the BOXN wagon. Most of the later designs are modifications and variant of the BOXN wagon.

BCN is a taller variant of BOXN wagon which is water tight covered bogie wagon with cartridge tapered roller bearings, cast steel bogie, air brakes and has two doors on each side. About 45,000 are in use on IR for foodgrains, cement etc.

In line with BOXN wagon, covered wagon BCNA for fertilizer, food grains and cement (bagged commodities), perishables etc.; tank wagon BTPN/ BTPGLN for carrying petroleum, LPG; flat wagon BRNA for carrying rails; finished steel plates, coils; coal; hopper wagon BOBRN were also introduced and all these are air braked wagons which now constitute nearly 72% fleet of wagons on IR.

The most common bogie tanker wagon primarily for liquid petroleum products (petrol, naphtha, kerosene, diesel, furnace oil, etc.), and also for molasses, vegetable oil, etc. an enhanced version, the BTFLN, has been developed recently.

Bogie tanker, for Liquefied Petroleum Gas (LPG) with tare weight 41.6 t, payload 37.6 t and carrying capacity of 79.4 m$^3$ has an axle load of 20.3 t, length over couplers 18.9 m, width 3.05 m, height 4.29 m and inside diameter of the tank is 2.4 m.

The carrying capacity for coal/ iron ore of a goods train has increased from 2697 t to 3387 t due to introduction of BOX/ BOXN wagons which has increased through put of goods train by 62% along with improved speed of freight trains and has reduced wagon turn-round.

Bogie rail-carrying flat car
BRH with roller bearings has end-plates that can be removed.

In 1998 to improve carrying capacity of freight train, RDSO developed BOXNHA wagon for higher axle load and higher capacity for increased coal tonnage. BOXNCR wagon with stainless steel body was developed for preventing corrosion. BOXNHS wagon was developed for higher speeds. BOST wagon was developed for steel products and coal. While developing BOXNHS wagons an attempt has been made to increase the speed of freight trains from existing 75 km/h to 100 km/h with the aim of reducing speed differential between freight and passenger trains on IR to permit more trains on congested routes. BOXN wagons fitted with ‘CASNUB’ HS (high speed bogies) raised the maximum speed to 100 km/h.

BLC wagons are CONCOR’s (1995) container flats (Also known as ‘CCF’, Coaching Container Flats). Low platform container flat wagons. These have light-weight welded ‘skeletal’ design underframes, automatic twist locks, a single-pipe air-brake system, and reduced wheel diameter (for the low beds). The low platform allows them to carry high-cube or Tallboy containers on routes where clearances would otherwise make this impossible.

**Other Developments:**

- The cast iron brake blocks wear fast, therefore, after detailed study and trials the cast iron brake blocks have been replaced by composition brake blocks which increases the reliability and reduces maintenance cost.
- Higher pay load wagons i.e. BOXNLW with cold rolled formed section and stainless steel body and BOXNAL, BOBRNAL wagons with aluminium body have also been designed to reduce the tare weight of wagons and improving the carrying capacity with permitted axle load.

**Current Development**

The track structure has been upgraded with 60 kg, 90 UTS rails over PSC sleepers and provided with CWR/ LWR. This has provided an opportunity to permit higher axle loads up to 22.9 t in general and 25 t axle load on special routes. Consequently, in later part of the 2005, BOXNHL wagon with 22.9 t axle load, having low tare weight and higher payload to tare weight ratio has been designed by RDSO for carrying coal and iron ore. As an improvement in the area of brakes, development of bogie mounted brake system to improve reliability of the system is also being done by RDSO. This is likely to provide opportunity for innovative designs of tubs in BOXN type wagon and well wagons to carry higher height consignments.

**Future Challenges**

The freight traffic is likely to increase to 1000 million tones/ annum in near future. Some of the areas in which action has been initiated are:-

- **Improved wagon designs:** Increasing freight requires increase in the trailing loads with more payload to tare weight ratio and higher axle loads. Encouraged by introduction of BOXN wagons over several important routes with CC+8+2 t, RDSO is moving in a direction towards universalizing 23 t axle load. CC is the design carrying capacity of the wagon and (8+2) or 10 t is the overload allowed on specified routes for iron ore etc. The design
of the 22.9 t covered wagon has been conceptualized. This will be for the length of BOXN wagon having width of 3500 mm equal to that of BOBRN wagon with height as per relaxed maximum moving dimensions for Garib Rath train. This will increase the volume per rake by 21% as compared to existing BCNA wagon. There will be an increased throughput of 36% for cement, 32% for food grains and 21.5% for fertilizer as compared to throughput of BCNA rake with permitted overload. 25 t axle load iron ore wagon (BOY 25 t) has been designed which will increase throughput of iron ore by 24% compared to existing BOY wagon with 22.9 t axle load. Conceptual design of 25 t axle load BOXN wagon has been made which will increase throughput by 14.5% over the rake of conventional BOXN wagons with CC+8+2 t loading. These designs will enable substantial increase in throughput without posing any line capacity problems.

- Development of higher axle load wagon of 25 t - 30 t;
- Introduction of track friendly bogie to reduce adverse effect on permanent way;
- Introduction of stainless steel or aluminum body wagon to increase pay load capacity of wagons;
- Introduction of commodity specific wagons such as RO-RO, auto racks etc.;
- Introduction of advance warning systems as hotbox detector, wheel flat detector, acoustic warning system and bogie performance monitoring system to improve reliability and safety of train operation with higher axle load.

Sri T.N. Tandon while working as Director/Wagon with his dynamic leadership and innovative ideas modified the BOX wagon and developed BOXN wagon. The BOXN wagon has sealed type cartridge taper roller bearings and cast steel ‘CASNUB’ bogie with high capacity draft gear and high tensile center buffer couplers. This wagon has several advantages over earlier BOX wagon and carries 30% more freight per rake than in the case of BOX wagon rake and has revolutionized the freight movement on IR.. The contribution of Sri Tandon is outstanding in the development of Railways for carrying more freight.
Testing Directorate

General

Testing of all new rolling stock including locos, carriage & wagon and testing vehicles breakdown cranes etc. was being done by a Testing Wing under Director (Research) since inception of RDSO. This wing was earlier headed by a Jt. Director, then by an Additional Director. In the year 1989 the present Testing Directorate was created for carrying out all dynamic and static mechanical testing activities related to all types of rolling stocks. This directorate is headed by Executive Director Research Testing.

This directorate undertakes design validation of all newly designed/ modified rolling stock developed, whether in-house or imported. In addition to oscillograph cars, dynamometer cars, instruments and recording equipments for field trials, the directorate has three laboratories for conducting simulated trials on rolling stock, sub-assemblies and its various components.

Laboratories:

1. Air Brake Lab: The main function of Lab is to study and optimise train brake characteristics with different types of distributor valves, multiple locomotive operations, varying leakage rate, compressor ratings and main reservoir capacity, effect of train parting, performance of distributor vales etc. The Lab is equipped with complete pneumatic circuit of 192 wagons and 30 coaches having twin pipe air brake system. Three locomotive controls stands can be used with any combination in the formation with varying compressed air flow rate up to 16 Kilo-litre per minute with seven compressors. The Lab is also equipped with single car test rig and endurance test rig for distributor valves.

2. Fatigue Laboratory: This Lab is installed for fatigue testing and structural strength analysis of bogie frames and their components for rolling stocks. These are tested by simulating service loads in order to optimise the design for the study of residual life of components and endurance test of rubber components etc. It is equipped with different type of load actuators from 10 t to 25 t loading capacity. It also has Universal Spring Testing machine.
data. One new dynamometer machine has also been commissioned in this Lab in September 2005 procured from M/s Schenck Pegassus GMBS, Germany. This new machine has an axle load range of 8 to 30 t, simulated inertia range of 200-6000 kg.m². This machine is capable of testing up to a speed of 300 km/h with 1000 mm dia wheel. This machine has a provision of testing of disc brakes also.

**Instrumentation of test vehicles**

Instrumentation of test vehicle is most important part of oscillation trials. Typical instrumentation for oscillation trial of ICF with rubber springs and GM locomotive bogie is shown below:-

3. **Brake Dynamometer Laboratory:** The dynamometer is extensively used for various types of tests and performance audit tests of composition brake blocks. Parameters commonly determined are coefficient of friction, wear rate and temperature rise in brake block and wheel. The effect of sustained down gradient and consequent application of brakes constantly up to an hour is also studied. The Lab is equipped with a gyrating mass brake dynamometer supplied by M/s MAN of Germany and is capable of testing up to a speed of 250 km/h, under simulation of axle load up to 25 t, brake torque of 4800 kgf.m and brake force of maximum 6000 kgf in wet and dry conditions, with continuous on-line recording and computerized analysis of
**R&D Activities**

The directorate has helped IR in considerable improvement in running safety, fuel economy, higher speed train operations, passenger comfort, increase in payload capacity of freight trains and reduced maintenance cost of various components of rolling stocks. It has several oscillograph cars, dynamometer cars along with facilities for instrumenting test vehicles and components by strain gauging and fixing transducers such as LVDT’s, accelerometers etc. along with electronic recording and computerised system for analysis of data. Oscillation trials and braking trials are done for clearing any new type of stock and/or for increasing its speed on different types of tracks. Some of the important contributions are listed below:

### 1957-70
- Introduction of first Rajdhani Express between New Delhi-Howrah;
- Test to study various causes of hot boxes;
- Test to determine the permissible shunting speed for BCX wagon.

### 1970-80
- Introduction of Rajdhani Express on NDLS-BCT at 120 km/h;
- Riding stability investigations at speeds up to 160 km/h;
- Design and development of Mobile brake laboratory; Brake dynamometer car; Brake dynamometer laboratory; Fatigue testing laboratory; and Impact test facility.

### 1980-90
- Development of composition brake shoe;
- Development of dynamic simulator for scale model studies, hunting simulator;
- Use of measuring wheel for BOXN wagon for measurement of vertical and transverse forces at Rail Wheel contact point;
- Introduction of 140 km/h high speed train on NDLS-AGC & NDLS-CNB section;
- Oscillation trials on BG Bogie hopper wagon type for bulk movement of food grains;
- Service trials to assess the use of low friction type composition brake blocks on Shatabdi Express train.

### 1990-2000
- Oscillation trials on BOXNHA wagon fitted with 23.5 t axle load IRF 108HS bogies up 110 km/h;
- Oscillation trials on enhanced capacity parcel van manufactured by Perambur shop up to 115 km/h;
- Oscillation trials on NDM₆ diesel locomotives up to a maximum test speed of 18 km/h on Neral-Matheran section of CR;
- Introduction of Computerised on-line Digital Recording.

### 2000-2006
- Development of Disc brake pads for wheel mounted disc brake arrangement;
- Brake test on 26-coach air brake passenger train with simulated automatic brake unit of anti-collision device developed by Konkan Railway;
- Brake test on 58 wagons air brake freight stock train with modified automatic brake unit & ant-collision device developed by Konkan Railway;
- Oscillation trials of 140 t BG diesel hydraulic breakdown crane Cowan’s design & built by M/s JESSOP & Co., Kolkata at max speed of 110 km/h;
- Oscillation trials on BG self-propelled accident relief medical van (SPARMV) on LKO-MB section of Northern Railway;
- Strength and endurance testing of high capacity buffer springs for side buffer of BG coaches;
- New brake dynamometer equipment procured from M/s Schenk Pagasus GMBH, Germany for axle load of 8 t to 30 t; Moment of Inertia 200 to 6000 kg.m²; and Maximum brake force of 60 kN;
- Upgradation of fatigue testing facilities in Fatigue Testing Lab;
- Development of Measuring Wheel Technology under Technology Mission for Railway Safety with IIT, Kanpur;
- Development of facility for simulated testing of locomotives in multiple-units in Air Brake Lab;
- Loco valve test facility in Air Brake Lab;
- Brake test on 58 wagons air brake freight stock train with modified train automatic brake unit and anti-collision device developed by Konkan Railway;
- Trials for successful introduction of Shatabdi trains up to 150 km/h speed.
- Oscillation trials of double stack containers have been conducted.
- Oscillation trials of BOBSNM1 with maximum load of 25 t has been conducted.
- Trials of prototype Garib Rath coaches (increased height) ad prototype coaches having pneumatic suspension at secondary has been conducted.

The work done by the directorate has been very useful to IR for design validation of all newly design/ modified rolling stock developed whether in-house or imported. Speed certificates are issued based on the trial results.
Traction Installation Directorate

**General**

The directorate was established in October 1968 and is presently headed by Sr. Executive Director (TI) from April 2004.

**Electric Traction**

The first electric train on IR ran in 1925 over a section of 16 km from Victoria Terminus (Mumbai) to Kurla at 1500 V DC. Closely following this development, the suburban section of Churchgate-Andheri-Borivili on WR was electrified. In 1954, suburban section of Calcutta area was electrified on 3000 V DC traction system. Later, after a detailed study of the electric traction system in use on important Railways abroad and taking into account merits/demerits of the different types of the AC and DC traction systems, 25 kV AC single phase 50 Hz electric traction system was adopted in 1957 as the standard for future electrification. The section of ER having 3000 V DC system was also converted to 25 kV AC traction system between 1958-67 to have uniform electric traction on IR.

When first Metro Railway in Kolkata was introduced in 1984, 750 V DC system was adopted because of less space available inside the tunnels.

With the growth of traffic, the power requirement of trains goes up to cater for increase in the speed, capacity and hauling load of the train. To meet the requirement 2 x 25 KV system was introduced between Bina- Katni section in 1995. The system is suitable for high loads and can meet IR’s future requirement.

The power supply for electric traction is taken from State Electricity Boards/NTPC through their transmission line network at 220/132/110/66 kV. The voltage is stepped down to 25 kV at traction substations (TSS), spaced at a distance of approximately 40 km to 60 km. The power supply is fed to 25 kV Overhead Equipment (OHE) and monitored by Supervisory Control and Data Acquisition (SCADA) System at remote control centre through switching posts.

The electric traction system was originally adopted from French Railways (SNCF) and most of the components/equipment were imported. There was an urgent need to indigenize various components and save precious foreign exchange. Further design modifications were done to make the equipment suitable for Indian environmental conditions and prevalent maintenance practices. Design changes have been done to increase reliability, maintainability and availability.

**Laboratories and Testing Facilities:**

- **Electrical Development Lab:** It is equipped with Vibration Testing Machine for vibration up to 9g with frequency varying from 10 Hz to 350 Hz and High Voltage Testing Machine for breakdown strength measurement of insulating materials from 0-50 kV. This lab is also equipped with contact wire wear test rig for checking wear of contact wire and Panto strips.

- **Traction Installation Lab:** It is equipped with Universal Tensile Testing Machine, FUT 20, for testing tensile strength of insulators. It is also equipped with Hardness Testers NB-250 & NB-3000 for testing hardness of metals.

In addition to above mobile test facilities viz. NETRA car and Thermovision camera are also maintained by TI lab.
R&D Activities

Development and improvements in the following area of power supply distribution & OHE have been done by the directorate since 1970 for indigenous supply of components, improved safety and economy:

- SCADA system;
- Protection system;
- Power factor compensation;
- Switchgears;
- Traction transformers;
- Lightning arrestors;
- Catenary and contact wire;
- Insulators;
- Tower wagons;
- OHE design;
- Civil design; and
- Automatic Tensioning Device (ATD) & Stainless Steel Wire Rope.

These improvements are on-going process and are still continuing to achieve more efficient, economical and safer system along with induction of latest technology. For example the improvements of SCADA system, Traction Power Transformers, Insulators (Porcelain and Composite), Lightning Arrestors, Contact wire and Power Factor compensation equipment have been done during various periods as indicated below and have brought about savings of hundreds of crores of rupees to IR over the years.

- **Traction Supervisory Control and Data Acquisition (SCADA) system:** Indian Railways have provided SCADA system for controlling 25 kV traction supply. It is done by controlling the switching ON/ OFF of circuit breakers & interrupters at traction substations (TSSs), Sub-Sectioning Posts (SSPs) and Sectioning Posts (SP) located at remote site. This control is exercised from a central location called the Remote Control Center. At present IR controls 25 kV Traction Supply of 17000 km of electrified territory through various Remote Control Centers.

  **1970-1980:** The SRC equipment of seventies comprised of mimic diagram board, the FMVFT switching equipment etc.

  **1980-1990:** With the introduction of minicomputer technology of eighties the specification of SCADA system was revised in 1986.

  **1990-2000:** With the advent of PC based technology, specification was again changed and new specification was issued by the directorate which was again amended in 1997.

  **2000-till date:** The standard SCADA software has been developed jointly by RDSO and M/s CMC Ltd, Hyderabad to tackle the problem of fast obsolescence of technology and to control the propriety of SCADA vendor. The communication protocol between Remote Terminal Units and Remote Control Center has been standardised to ensure interchangeability of Remote Terminals Units between various SCADA vendors. The specification no. TI/SPC/RCC/SCADA/0986 has been issued in 2001.

- **Power Factor (p.f.) Compensation Equipment:** In the initial stage of electrification with 25 kv AC, 50 Hz, single phase traction system, the Traction Sub-Station (TSS) were owned and maintained by electricity supply authorities. In the late sixties, IR started owning and maintaining their own TSS, purchasing bulk power from various State Electricity Boards. Electricity Boards started levying low p.f. penalty charges on IR from 1975. Therefore, to avoid penalty, it became necessary for the
Railways to provide shunt capacitor units at all the TSS where power supply agreement imposed penalty for low power factor. First shunt capacitor unit was installed at Krishna Canal TSS of SCR on 25.12.82. Following are the R&D activities taken up, which have resulted in saving of hundreds of crores of rupees to IR:-

1980-1990
- The first specification for shunt capacitor was issued, which had capacitor banks with paper and PCB (Polychlorinated Biphenyl Phenyl) insulation to reduce losses. Paper and the PCB based dielectric was replaced by pp film (Polypropylene) and PXE (Phenyl Xylene Ethane). The specification for shunt capacitor was revised by incorporating latest changes in manufacturing technology.
- Revised specification for thyristor switched capacitor was issued to avoid penalty on leading p.f. also.
- Due to technological development in semi-conductor switching devices, Specification for Dynamic Reactive Power Compensation was issued. by incorporating the latest technology. The first IGBT based Dynamic Reactive Power Compensation was installed in October 2005 which gives p.f. close to unity

Lightning Arrestors:

Indian Railways have provided Lightning Arrestors at traction sub-station, sectioning post and sub-sectioning post to discharge over voltages to earth and prevent service interruptions.


1980 –1990: The gap type LA had number of drawbacks and to overcome these, Metal Oxide Gapless type lightening arrester has been developed.

1990 – 2000: Specification revised to include new features of the system.

2000–Till date: Condition monitoring of lightning arrestors introduced.
- RDSO has prepared specification for measuring the third harmonic resistive component (THRC) leakage current of lightning arresters.
- RDSO has issued maintenance instruction no. TI/ MI/0041 Rev. 0 for proper maintenance of LAs.
- Lightning Arrestors showing THRC (third harmonic resistive current) more than 1000 micro Amp were removed from service to avoid major blasting/ failures.
• **Catenary and Contact wire:**
  - Initially hard drawn grooved contact wire manufactured with silver brazed joints was used by IR. Subsequently, Electric Resistance Butt Welding (ERBW) and Cold Pressure Butt Welding (CPBW) jointing technique developed.
  - In 1997, RDSO issued the technical specification for HDGC wire drawn out from continuous cast copper wire rod and Railway Board instructed CORE & Railways for procurement of HDGC wire drawn from CCC rods only.
  - RDSO again revised specification in 2005 incorporating the following:-
    - To ensure a rigid compliance of the process and reliability of the end product, a Customer Hold Point (CHP) introduced in the specification.
    - Electric Resistivity test on CCC wire rod included in acceptance and type test
    - CCC wire rod diameter modified. Tolerance on dia of CCC wire rod included.
  - In 2006 Railway Board issued instructions that in all future procurement only HDGC contact wire manufactured from CCC wire rod as per RDSO Specification will be procured for all sizes of contact wires including Mumbai area for AC & DC system.

  **Traction power transformers:** This was modified and improved in following stages:-

  **1970-1980:** Railways decided to use indigenous traction transformer with capacity of 7.5/10/12.5 MVA for railway’s independent traction sub - stations. Dependability on State Electricity Board eliminated.

  **1980-1990:** Developed traction power transformer with rating of 21.6 MVA which enhanced voltage regulation and met traffic growth.

  **1990-2000**
  - Use of inhibited mineral insulating oil in place of un-inhibited mineral insulating oil which arrested premature failure of transformer due to contamination of oil;
  - Provision of forced air cooling deleted, which cut down the cost of Transformer by about 30%.
  - Capitalization of losses was reduced by reducing no-load and load losses.

  Studies were carried out and tests/methods for the condition monitoring and assessment of residual life of transformers through Dissolved Gas Analysis, Partial discharge, Light absorbance technique, Degree of polymerization & Furan analysis etc. were introduced. By this method, failure prone transformers are identified in advance so that planning of its rectification/replacement can be done without any repercussion on traffic.

  **2000-till date**
  - Improved quality of core material which has helped to reduce constant losses.
  - Elimination of core bolts thus reducing failure of transformer due to earthing of core bolts.
  - Codal life of transformers has been fixed as 50 years. Considerable saving achieved as it eliminated premature withdrawal of healthy equipment from service.
  - Increased substation spacings, which has resulted into less number of neutral sections, lesser maintenance requirement and better control of maximum demand along with improvement of power factor.

**Insulator:**

- **Porcelain Insulator:** On IR there are approximately 17 lacs porcelain insulators on 25 kV AC traction system spread over 44000 electrified tracks km. There are
number of failures of porcelain insulators on account of flashover, mechanical breakage, vandalism etc. About 70% failures are on account of mechanical breakage, which are generally catastrophic and disrupt traffic.

1980–1990: Quartz having Alumina based porcelain insulators were developed by RDSO in early eighties. Creepage distance was standardized; Quality index, Artificial pollution test, Thermal mechanical test were introduced; Mechanical performance test and Bending tests were revised.

1990–till date: While keeping in mind the mechanical breakage, the material of porcelain i.e. Quartz replaced by Alumina with 45% minimum was introduced in 1991. Tests were introduced for bulk density, flexural strength, modules of elasticity, power arc and chemical composition. Mechanized assembly, routine ultrasonic testing on both side along with inspection by RDSO were also introduced.

Composite Insulator: The material used for manufacture of insulators have been conventionally porcelain and glass, both have good insulation characteristics and excellent weather resistance properties but have disadvantages of being heavy, poor resistance to impact, poor electrical withstand characteristics under contamination. To overcome these problems composite insulators have been developed and adopted on IR. The composite insulator has a core of glass fiber and polymer sheds. The load is transmitted to the core through metal fitting attached to the core at two ends. The sleeve material has excellent hydrophobic and anti-tracking properties. These insulators have the following advantages over traditional insulators:-

- Light weight with the advantage of transportation, low maintenance cost and less load on mast;
- High resistance to gun shots and vandalism;
- Greater strength to weight ratio;
- Less energy loss due to leakage current.

1990–2000: The first composite insulator of EPDM and EVA sleeve material with heat shrinkage method was developed for IR around 1999.

2000–till date: Silicon rubber composite insulators with injection moulding method was developed for IR and is being standardized after field trials.

Civil Design:

1970–90: Improvements were made in the designs to achieve economy such as:-

- Short upright in ‘N’ type portal in platform have been developed in place of normal length upright with saving of 7% in steel.
- Spun pre-stressed concrete mast has been developed in lieu of 152 mm × 152 mm broad flange beam steel mast which costs 50% less.
- Alternate arrangement of gantry with tower T\textsubscript{1}, T\textsubscript{2} with beam B\textsubscript{1} in place of column C\textsubscript{1} with beam B\textsubscript{2} in 132/25 kV traction sub – station was developed with savings of Rs. 95,000 per sub station of type I, II, IV, VII, VIII, IX and X and Rs 50,000 per sub-station of type III, V and VI.

1990–2000: The designs of OHE structures were further improved to bring in economy such as:-

- Reduction in length of rolled drop arm for Tramway type OHE with saving of 33 kg of steel per drop arm;
- Simplified switching station (3 interrupters) with saving in foundation and structure of about Rs. 35,000 per station;
Development of Tapered Steel Mast (TM series) in place of rectangular straight steel mast for OHE.

Simplified sectioning and paralleling station by deleting the provision of double pole isolator and separate structure for AT. Now it has been mounted on one of the upright of portal. This has resulted in saving of structure and foundation costing Rs. 38,000/- per station.

2000-till date: Further improvements are continuing with new and improved designs of portals, foundations and height gauge etc.

Automatic Tensioning Devices (ATDs) and Stainless Steel Wire Rope: ATDs are used with stainless steel wire rope to maintain a constant tension in OHE conductors, irrespective of the variation in temperature due to expansion and contraction. ATDs are provided at both the ends of each tensioning length. Various types of ATDs have been used over IR. Initially, twin block 5 pulley type ATD was introduced in sixties. Winch type ATD was introduced in 1964 with design from SNCF and there are still about 33,000 winch type ATDs in use.

3 Pulley type ATD was introduced in 1985 to overcome the problem of over sliding of rope, misalignment etc. in winch type ATD. Pulley type regulating equipment with 3:1 ratio were designed and adopted. The pulleys used in this ATD were of 140 mm diameter. Due to smaller bending radius of the rope on these pulleys, caused early fatigue and therefore bigger pulley of 250 mm diameter were introduced in 1999 and from 2000 onwards, all the ATDs being installed over IR are of 3 pulley type with pulley dia of 250 mm, having population around 31,000 on IR.

In 2006, RDSO has revised the Specification to improve reliability by incorporating criteria like Tensile strength, increasing breaking load of wire rope and introduction of lubrication during manufacturing. This has yielded enhanced endurance test cycle from 7000 to 18000. Further, RDSO carried out study in the design of pulley of ATD and it’s groove profile has been modified based upon the practices of other Railways in abroad. This has resulted into endurance test cycle of 34000 with an improvement in service life which is 5 times over the existing design.

Other important achievements: The directorate have also carried out major developmental work in the following field:-

- Development of Network of Electrification, Testing & Recording Apparatus (NETRA car);
- Development of Thermo vision system;
- Development of Oliver system;
- Development of Carbon strip for use on Pantograph.

Development of NETRA car: NETRA car measures and records various parameters of OHE (Overhead Equipment) and pantograph under static and dynamic conditions under live and non-live conditions of OHE at 105 km/h. The quality of current collection is monitored for directed maintenance of OHE and to evolve
improved design of OHE and pantograph for field trials. The abnormality reports of recording done on different Railways are advised to the Railways for attending the observations.

NETRA project was sanctioned in June 1995 and a purchase order was placed by Railway Board on M/s BHEL for modification, furnishing and instrumentation of OHE Recording-cum-test car in June 1997. The car has been developed at a total cost of Rs. 6.83 crores. The concept and design is by RDSO. The NETRA car has an IRY coach with IR-20 bogie and is fitted with air-brakes. It is permitted to carry out recording at a speed of 105 km/h only. The coach was manufactured by Rail Coach Factory, Kapurthala in 1998. The coach was modified and furnished by M/s BHEL, Jhansi. The instrumentation and software was supplied by M/s Surrey Material and Inspection system, U.K. & M/s Ashida Electronics, Mumbai. NETRA car was commissioned on 19.05.2000 and put into operation in June 2000.

- **Development of Thermo Vision System:** Infrared thermal measurement and image processing system is used for condition monitoring of current carrying joints of OHE and PSI installations. It is available with RDSO since 1999 and used by RDSO and Zonal Railways. The thermal imaging system is capable of carrying out thermal measurement under live line in hand held static condition as well as in mobile condition from OHE Inspection Car. Major applications in railway traction are envisaged for the condition monitoring of different type of OHE joints of various jumpers, feeder wires, earthing connections, crimped/ soldered joints on OHE, joints on transmission lines, circuit breaker/ interrupters poles, lightning arrestors, current carrying joints of various power supply equipment.

- **Development of Oliver system:** The system will be used for overhead line inspection with video recording and GPS marking system for current collection test (Oliver-G) and analyzing current collection test between the 25 kV AC overhead contact line and the pantograph of the electric loco to identify localized irregularities in the contact line to increase reliability of OHE resulting improvement in punctuality of trains. RDSO has prepared a technical Specification and issued to all Zonal Railways in 2006.

The Traction Installation Directorate since its inception has been bringing out continuous improvements through its R&D activities and design modifications based on state of the art technology and experience in the electric traction on IR.
General

The directorate is working under Sr. Executive Director (Electrical) since 2001. Earlier it was headed by ED (Electrical)/Director Standards (Electrical) since 1969. At the time of merger of CSO and RTRC, there was an Electrical Wing under Director Standards (Mechanical) at CLW, Chittaranjan. This was subsequently shifted to RDSO, Lucknow and independent Electrical Directorate was created.

Electric traction was introduced in 1925 in India. This was 1500 volts DC system. The 25 kV AC system was introduced in 1957, coincidentally the year in which RDSO was born. Since the modest beginning made at that time, Electric loco has seen remarkable developments in terms of haulage capacity as well as reliability. As on 31st March 2005 on 27.33% of the total route kilometer of IR which is electrified carries 62.9% of BG freight GTKM and 47.5% of passenger train km. There were 3065 electric locos out of a total of 7910 locos on IR as on 31.3.05. The directorate has been constantly upgrading the locos to higher horse power with better operating efficiency and capable of running at higher speeds.

Electric Locos

A brief of various generations of locos taking shape in past five decades is as under:-

<table>
<thead>
<tr>
<th>Decade</th>
<th>Loco type</th>
<th>Salient features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960s</td>
<td>WAG1 (2900 hp)</td>
<td>Design from 50 Cycles European Group; Maximum Speed 80 km/h; Excitron Rectifier with regeneration; Mono motor Bogie, Fully suspended Traction Motor - Type MG1420; Control by HT Tap changer (N-32).</td>
</tr>
<tr>
<td></td>
<td>WAG2 (3260 hp)</td>
<td>Received from Hitachi, Japan; Maximum speed 80 km/h; provided with silicon rectifier with Rheostat braking; control by HT tap changer (N-32); traction motor type - HS1091 of Hitachi make; fully suspended.</td>
</tr>
<tr>
<td></td>
<td>WAG4 (3150 hp)</td>
<td>Indigenously built, derived from WAG1 loco; Maximum Speed 80 km/h; Silicon Rectifier with Rheostat braking; Mono motor Bogie, Fully suspended Traction Motor - Type MG1580; Control by HT Tap changer (N-32).</td>
</tr>
<tr>
<td>1970s</td>
<td>WCG2 (4200 hp)</td>
<td>Maximum Speed 80 km/h; Three axle tri mount cast bogie; Axle hung nose suspended traction motor - HEIL make, TM4939AZ, force ventilation; Vernier control on main starting resistance.</td>
</tr>
<tr>
<td></td>
<td>WAG5A/H (3850 hp)</td>
<td>Derived from WAM4; Maximum Speed 105 km/h; Silicon Rectifier with Rheostat braking; Axle hung nose suspended traction motor - Type HS15250; Control by HT Tap changer (N-32).</td>
</tr>
<tr>
<td></td>
<td>WAG6A (6280 hp)</td>
<td>6 Locos received from M/s ASEA, Sweden; Maximum Speed 100 km/h; Thyristor Controlled; Bo-Bo-Bo Bogie, flexible secondary Hollow shaft Drive; Fully suspended traction motor - Type L3 M 450-2.</td>
</tr>
<tr>
<td></td>
<td>WAG6B (6050 hp)</td>
<td>6 Locos received from M/s Sumitomo Corp, Japan; Maximum Speed 100 km/h; Thyristor Controlled; Bo-Bo-Bo bogie; Traction Motor - Type HS 15556-OIR.</td>
</tr>
</tbody>
</table>
### WAG6C (6050 hp)
6 Locos received from M/s Sumitomo Corp, Japan; Maximum Speed 100 km/h; Thyristor Controlled; High Adhesion Co-Co Bogie; Axle hung nose suspended traction motor - Type Hitachi HS15256-URL.

### 1990s WAG7 (5000 hp)
Concept of Fabricated high adhesion Bogie similar to WAG6C used; Axle hung nose suspended traction motor - Type HS-15250A Hitachi; Maximum Speed 100 km/h; Silicon Rectifier with Rheostat braking; Control by HT Tap changer (N-32).

### 1998 WAG9 (6120 hp)
Received from M/S ABB, Switzerland with transfer of technology; Maximum Speed 100 km/h; 3-Phase VVVF Control; GTO based Propulsion System; Regenerative & Air brake; Co-Co fabricated bogie; Axle hung nose suspended 3-phase squirrel cage induction motor – Type 6FRA6068.

## Passenger Locos:

<table>
<thead>
<tr>
<th>Decade</th>
<th>Loco type</th>
<th>Salient features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960s</td>
<td>WAM1 (2870 hp)</td>
<td>First AC Electric Loco on IR received from 50 cycle European Group and put into service in 1960; Maximum Speed 112 km/h; Two axle fabricated bogie, with Jaquemin Drive and pendular suspension arrangement; Four water-cooled ignitrons type SGT; Fully suspended Traction Motor type MG710A; Control through HT N-40 Tap Changer.</td>
</tr>
<tr>
<td></td>
<td>WAM2 (2790 hp)</td>
<td>Received from Mitsubishi, Japan in 1961; Maximum Speed 112 km/h; Bo-Bo fabricated Bogie, Power transmission through flexible WN Gear Drive; Water-cooled ignitrons from Mitsubishi; Fully suspended Traction Motor type Mitsubishi MB 3045-A; Control through HT N-40 Tap Changer.</td>
</tr>
<tr>
<td>1970s</td>
<td>WAM4 (3400 hp)</td>
<td>New Design Concept; Cast CO-CO Bogie of Alco design received with WDM2 loco; Maximum Speed 120 km/h; Silicon Rectifier with Rheostat braking; Traction Motor - Type TAO-659; Axle hung nose suspended; Control by HT Tap changer (N-32).</td>
</tr>
<tr>
<td>1980s</td>
<td>WAP1 (3800 hp)</td>
<td>Indigenously built using Flexi-coil Cast Bogie &amp; Bolster similar to WDM4 loco received from General Motors, USA; Double Suspension; Maximum Speed 130 km/h; Silicon Rectifier; Axle hung nose suspended force-ventilated; Traction Motor type - TAO-659; Control by HT Tap changer (N-32).</td>
</tr>
<tr>
<td>1990s</td>
<td>WAP4 (5000 hp)</td>
<td>Maximum Speed 140 km/h; Control by HT Tap changer (N-32); Silicon Rectifiers; CO-CO Flexi coil Mark 1 Cast Bogies same as in WAP1; Axle hung nose suspended force-ventilated; Traction Motor type - Hitachi HS15250 having provision of roller suspension bearing.</td>
</tr>
<tr>
<td>1995</td>
<td>WAP5 (5440 hp)</td>
<td>Received from M/S ABB, Switzerland with transfer of technology; Maximum Speed 160 km/h having speed potential of 200 km/h; Air &amp; Regenerative braking; GTO based Propulsion System; Bo-Bo Flexi float Bogie; 3-phase Squirrel Cage Induction Motor – Type 6FXA7059; Forced-air ventilation, fully suspended</td>
</tr>
<tr>
<td>2000</td>
<td>WAP7 (6000 hp)</td>
<td>Designed by modifying the gear ratio of WAG9 loco; Maximum Speed 130 km/h; Regenerative braking; GTO based Propulsion System; Co-Co, Fabricated Bogies; 3-phase Squirrel Cage Induction Motor – Type 6FRA6068; Axle-hung, nose- suspended traction motor.</td>
</tr>
</tbody>
</table>
Photographs of WAG1, WAG5, WAG6C & WAG9 (freight locos) and WAM1, WAM4, WAP4 & WAP7 (passenger locos) are given in the end of the chapter.

The traction equipments used on Electric locos worldwide have undergone tremendous improvements involving use of state of art technologies, especially in the field of power and control electronics and material science. The Electrical directorate has played a proactive role in monitoring the trends in the electric loco technologies world over and constantly updating the loco equipments with more efficient and cost effective technology for enhancing their speed potential and haulage power. The important salient developments having taken place in last 5 decades are as follows:-

- Introduction and indigenous manufacture of Hitachi Traction Motor with roller suspension bearing in lieu of plain sleeve suspension bearing at CLW against technology transfer from M/s Hitachi, Japan.
- Upgradation of the horse power of passenger and freight indigenous built electric locos from 2900 hp to 5000 hp.
- Increase of speed potential of indigenous built freight locos from 65 km/h to 100 km/h and indigenous passenger locos from 100 km/h to 140 km/h.
- Successful introduction and indigenous manufacture at CLW of high horse power electric locos, with state of art technology having 3-phase drive system, WAP5, WAP7 & WAG9 locos having unique feature of regenerative braking enabling retrieval of electrical energy and feeding back to overhead system against technology transfer from M/s Bombardier Transportation (originally M/s ABB), Switzerland.
- For traction motors, the class of insulation has been upgraded to class 200 from class H. The needs of replacement, rewinding and other unscheduled repairs/arising have come down drastically with improved reliability.
- Since 1991, all traction motors are manufactured with roller bearings. Use of roller bearings in place of plain sleeve suspension bearings for traction motors has resulted into low maintenance and increased in periodicity of maintenance schedules resulting in reduced maintenance cost.
- TAO659 traction motors have been modified for provision of roller suspension bearings in place of failure prone plain sleeve suspension bearings and are being provided in WAG5A, WAP1 & WAM4 locos in a phased manner, resulting in better reliability and safety of loco.
- Introduction of Rockwell Technology for casting of Co-Co Bogie at CLW to take care of the problem of development of frequent cracks in Co-Co bogies casted at CLW steel foundry;
- 6P Conversion of locos has resulted in improving the reliability of traction motors leading to over all improvement in reliability of WAM4 loco and improved punctuality.
- Stainless Steel RGR have been developed and provided in the locos to

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Sri Sanat Kumar Kanjilal was the first Jt. Director Standards (Electrical) and served up to November, 1969 at RDSO, Lucknow. He was pioneer in the design of locos fitted with trimount Co-Co bogies of Alco design and built at Chittaranjan, saving millions of foreign exchange. These locos became the backbone for operation of both passenger and goods traffic.
eliminate the problem of melting of Cast Iron RGR.

- Introduction of Vacuum Circuit Breaker (VCB) requiring less maintenance and more reliable, in lieu of Air Blast Circuit Breaker in electric locos since 1987-88. The initial VCBs were having twin bottles, which have now been upgraded, to more reliable single bottle VCBs from 1998 onward.
- The introduction of metallised carbon strips in pantograph has resulted in increased life of contact wires and almost nil maintenance of pantograph. The wear of contact wire has reduced by about 25%.
- Introduction of AM-92 High Speed Pantograph having special feature that will not result in damage to OHE in the event of panto-entanglement;
- Introduction of 180 kVA Static Inverter in place of rotary Arno converter of 120 kVA for feeding the 3-phase supply to auxiliary motors. There have been no failures of auxiliary machine which used to take place with Arno converters due to unbalanced supply. This has also enabled provision of AC-MVRF resulting in availability of higher braking effort on larger speed band and hence improving safety.
- Development of smoothing reactor (SL-30) in place of earlier SL-42;
- The introduction of low maintenance batteries has resulted in avoiding toping up of water during trip schedules;
- Roof Mounted DBR has been developed for provision in passenger electric locos. The introduction and working of DBRs and their extensive application by running staff has resulted into lesser wear and tear of wheels along with better control of train specially in Ghat sections, thus enhancing safety. The life of brake block and wheel disc has increased leading to less consumption of brake blocks/wheel disc.
- With the continuous technological upgradation in the field of insulating materials, it has been possible to upgrade the transformers from initial 3000 kVA to 5400 kVA which has enabled to increase the horse power of loco to meet the traffic requirement of hauling higher loads at higher speeds.
- The use of high quality (inhibited) transformer oil has reduced the maintenance requirements of transformers as well as tap changers along with the added advantage of less failures and more service life.
- The introduction of vertical cable head termination in place of conventional paper based condenser bushings has improved the reliability, maintenance requirements and increase the service life and helped in avoiding fire in electric locos which used to take place due to bursting of paper based condenser bushing.
- Microprocessor based speed-cum-energy monitoring system with recording facility of data of speed and energy for 60 days along with other additional features are being provided in place of speedometers with strip chart recording requiring change of strip chart paper after 7 days.
- Microprocessor based control & fault diagnostic system has been developed to eliminate failure prone electromechanical relays from the control circuit. This system is gradually being provided on all Electric locos.
- The Electron Beam irradiated Cross Linked Cables developed by RDSO are being used on all new locos. These cables are thin walled, fire retardant, low toxic, higher temperature withstand capability of 120°C and higher current density and will not require re-cabling during the life of loco. The earlier design of cables with EPR insulation and CSP sheath were suitable for
a temperature of 90°C and a mid life re-
cabling was necessary.

- To improve reliability of pneumatic
circuit, panel mounted pneumatic brake
panels have been developed and being
provided during new manufacture and MTR
in all locos.
- Electro pneumatic contactors have been
upgraded to 1500 A against 1000 A to
improve the reliability.
- Twin beam head light with DC-DC
converter have been provided in the locos
to improve the visibility in the night for
enhanced safety.
- LED based Flasher Light have been
developed and provided on the locos, which
gives better visibility to approaching train
in the event of any unsafe condition. These
lights are more reliable due to elimination
of incandescent bulb.
- The incandescent lamp of marker light
used to fail, which have now been replaced
by LED type marker light ensuring
availability, better visibility and reliability.
- The use of high sump capacity
compressors has reduced the frequent
topping up of oil, thereby increasing
availability of the loco.
- With introduction of air dryers, the
reliability of the pneumatic valves has
improved.

The above technological up-
gradations have resulted in:

- Increasing the periodicity of schedule
inspections as per Railway Board’s letter
No.92/Elec(TRS)/138/5 Pt I dated
18.01.01& 18.10.01 and 2003/Elect/TRS/
138/3 dated 24.12.03 as under:-
- Seamless operation of locos i.e. end-
to-end running even with goods locos
beyond adjoining railway boundaries as per
Railway Board’s letter No.2001/Elec(TRS)/
440/5 dated 28.11.01 and 15.7.04, which has
brought revolution in train operation and
enable IR to carry 667 million ton during
2005-06 with hardly any increase in loco
population.
- Reduction in man power from more
than 7 men per loco to 5.5 men per loco for
Hitachi TM fitted locos and 6.5 loco to TAO-
659 TM fitted locos as advised by Railway
Board vide letter No. 2001/Elect(G)/138/3
dated 16.03.06.
- Increase in productivity of freight
electric locos from 3.25 lakh NTKM per loco
per day during 98–99 to 5.22 lakh NTKM
per loco per day.
- Running of 58 BOX N loaded trains
with single WAG7 loco.

Future Plan

The challenges of providing higher
throughput with improved reliability of
rolling stock have made it necessary to
continuously search for better technologies
for the locos and equipments. The
directorate has been continuously striving
to achieve this objective. The major efforts
being made in this direction are as follows:-

- Development of high horse power
IGBT based Electric freight loco: To meet
the challenge of requirement of motive
power for dedicated freight corridor,
development of high horse power (8000 hp
or more) IGBT based Electric freight loco
has been taken up. The specification has been
finalised.
- Development of Crew friendly cab:
Development of ergonomically designed
crew friendly cab has been undertaken to
reduce the fatigue of drivers enhancing
safety of operation.
- Provision of smaller size rectifier &
BA panel: In order to save space on Board
to facilitate more spacious cabs, RDSO has
<table>
<thead>
<tr>
<th>S.N.</th>
<th>Maintenance Schedule</th>
<th>Passenger Locos</th>
<th>Goods locos</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Prior 2001</td>
<td>Existing</td>
</tr>
<tr>
<td>1.</td>
<td>Trip inspection</td>
<td>2500 km</td>
<td>3000 km</td>
</tr>
<tr>
<td>2.</td>
<td>IA</td>
<td>30 days</td>
<td>40 days</td>
</tr>
<tr>
<td>3.</td>
<td>IB</td>
<td>60 days</td>
<td>80 days</td>
</tr>
<tr>
<td>4.</td>
<td>IC</td>
<td>90 days</td>
<td>120 days</td>
</tr>
<tr>
<td>5.</td>
<td>AOH</td>
<td>12 months</td>
<td>12 months</td>
</tr>
<tr>
<td>6.</td>
<td>IOH</td>
<td>36 months or 3 lacs km whichever is earlier.</td>
<td>36 months or 6 lacs km whichever is earlier.</td>
</tr>
<tr>
<td>7.</td>
<td>POH</td>
<td>6 years or 6 lacs km whichever is earlier.</td>
<td>6 years or 12 lacs km whichever is earlier.</td>
</tr>
</tbody>
</table>

finalised the design of smaller size rectifier and BA panel. The development is under progress.

- **High capacity reverser:** To improve reliability of failure prone CTF and Reverser RDSO has upgraded the design of Reverser with current capacity of 1500 A instead of existing 1000 A.

- **Vigilance Control Device:** To keep a watch on alertness of drivers, Vigilance Control Device has been developed and put on trial on 30 locos.

- **Air Raised Pantograph:** More reliable and maintenance free air raised pantograph has been introduced on few locos, to be provided on more and more locos in phased manner in future.
Photographs: Single Bottle Vacuum Circuit Breaker:

Areva Design

Secheron Design

Air Raised Pantograph

Roof Mounted DBR

Electric Loco Simulator for WAP4/WAG7/WAG9

Static Inverter
Codes, Manuals and Standards:

The number of important Manuals and Standards in which the Directorate has contributed significantly is given below:

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Sri A. A. Hattangadi, who was Director Standards (Electrical) from December 1976 to December 1981, has made the maximum contribution in the field of improvement in reliability of electric locos. He introduced the standard system of failure reporting, investigation and analysis of electric loco equipment. Sri Hattangadi was instrumental in design of WAP1 class of Electric loco for hauling Rajdhani Express train, which was designed and manufactured totally indigenously at CLW.
Freight locos:

WAG1, 2900 hp

WAG5, 3850 hp

WAG6C, 6050 hp

WAG9, 6000 hp

Passenger locos:

WAM1, 2870 hp

WAM4, 3400 hp

WAP4, 5000 hp

WAP7, 6000 hp
Power Supply & EMU Directorate

General

Power Supply & EMU Directorate was carved out by reorganizing Electrical Directorate and started functioning since August 1995, headed by Executive Director. The Directorate has been fully engaged in developing design and standardisation of Electrical Equipment and Systems for EMUs, Metro Rolling Stock, Train Lighting, Air Conditioning and power supply related items of the coaches and development of initial vendors for these items, with a view to achieve the quality objectives for improved suburban and main line services to Railway passengers in terms of better comfort, safety, reliability, efficiency and maintainability of the equipment.

R&D Activities

The equipments used on coaches worldwide have undergone tremendous improvements involving the use of state of art technologies, especially in the field of power and control electronics and material science. Adopting the advances in technology, the important salient developments having taken place since the creation of PS&EMU Directorate are as follows:-

- **Development of 4.5 kW Brushless Alternator for Non AC Coaches:** This was major step towards less maintenance. Earlier DC generators (dynamos) were used.
- **Development of 25 kW Brushless Alternator for Self Generating AC Coaches:** With the development of AC 3 tier coach having Roof Mounted Package Unit, load of the coach increased. 25 kW alternators were developed to meet the load requirements.
- **Provision of Over Voltage Protection in Rectifier-cum-Regulator Units of Alternator for Train Lighting of Coaches:** In non AC coaches, there was no protection for over voltage generation. It has been developed to eliminate fire hazard due to over voltage.
- **Design & Development of Electronic Voltage Regulator for 4.5 kW/25 kW Brushless Alternator to be used on TL/AC Coaches:** Electronic Rectifier-cum-Regulator Unit was developed to achieve better regulation and low ripple content in DC output. It has the feature to give controlled charging to the battery i.e. with maximum current limit.
- **Development of Low Maintenance Lead Acid Batteries from 120 AH to 1100 AH, for Passenger Coaches:** Initially 6 V, 120 Ah and later 2 V, 1100 Ah batteries were developed in which there is no need to add water up to 6 months.
- **Development of Valve Regulated lead Acid batteries for AC Coaches:** These batteries are sealed, smaller in size and can be fitted in limited space available. These batteries are successfully working in AC coaches.
- **Development of Roof Mounted AC Package Unit (6.5T capacity):** Earlier the AC coaches were provided with underslung type air-conditioning system on 110V DC. RMPU with R-22 refrigerant has been developed which is working at 415 V AC to improve the efficiency, reliability as well as reduction of weight of the air conditioning system.
- **Development of Electronic Thermostats for Roof Mounted AC Package Unit:** Earlier Mercury in glass thermostats were being used on AC coaches to regulate the temperature inside the air conditioned
Reliability and temperature regulation was poor and giving frequent trouble. Electronic Thermostats have been successfully developed and adopted to improve the reliability and accuracy of the temperature regulations inside the air conditioned coaches.

- **Development of 25 kVA underslung Inverter for AC Coaches:** Roof Mounted Package Unit (RMPU) for Air Conditioning of coaches has been developed which is working on 415 V 50 Hz, PWM AC supply. Power supply to RMPU was being fed through forced cooled On-Board inverter. Due to cooling problem, Natural cooled underslung inverter has been developed which is almost maintenance free, more passengers friendly due to low noise level and also space for two berths in 2nd AC coach and for linen in 3 tier AC coaches made available.

- **Development of 672 kW High Capacity Power Cars for Rajdhani Trains:** The existing power cars of Rajdhani/ Shatabdi Trains are having 2×250 kW Diesel Alternator Sets which are capable to feed Rajdhani trains with maximum 19 (17+2 Power Cars) coaches. High capacity power cars of 2×336 kW Diesel Alternator Sets have been developed which can feed entire load of 23 (21+2 Power Cars) coaches of Rajdhani/Shatabdi trains to cater the increasing demand of traffic.

- **Noise Level Reduction in Power Cars:** The noise pollution form existing power cars due to Diesel Alternator sets is in the range of 95-100 dB. Keeping in view of passenger discomfort, one power car has been modified on trial basis and noise level has been reduced to 75- 80 dB.

- **Development of Energy-cum-Speed Monitoring System for EMU:** To indicate and record consumed energy in KWH, speed and distance parameters for improving the driving techniques and awareness of the drivers. Southern Railway has recorded 10% reduction in Specific Energy consumption (SEC) by utilizing the features of Energy-cum-Speed Monitoring System (ESMON).

- **Reduction in running time of Main Line EMUs:** By provision of field weakening arrangement in the existing 4601 AZ/BX traction motors increase in the acceleration and average speed of the trains has been achieved. The reduction is of the order of 6 minutes/100 km in run time at 90 km/h maximum speed and 8 minutes/100 km in run time at 100 km/h maximum speed.

- **Development of Motor Alternator set for DC EMUs:** RDSO has developed 18 KW MA set for DC EMU indigenously through M/s BHEL, which was originally being supplied by M/s TDK.

- **Design & Development of dual voltage 3 phase drive electrics for existing BG DC EMUs (GEC Alstom & BHEL Project):** Mumbai suburban EMUs were running on 1500V DC traction. With the development of dual voltage 3 phase drive system, EMUs are able to run on both the DC & AC traction system.

- **Development of Brushless DC fans (BLDC Fans):** BLDC fans are developed to replace the DC fans. These fans are with the features of energy efficient, less noise, light weight, maintenance free, unidirectional rotation irrespective of supply polarity.

**On Going Projects & Future Plan:**

- The major efforts made are as follows:-

- **Design and Development of Head on Generation (HOG) System:** At present self-generating and End On Generation system is being used for meeting the electrical load requirements of train lighting,
air conditioning and pantry car equipments. Development of Head on Generation has been under taken where the supply is taken from loco to achieve the cost effective, reliable and energy efficient power supply system.

- **Use of Eco-friendly refrigerant on underslung AC coaches**: Existing designs of underslung type AC coaches are working with CFC (R12) refrigerant which need to be phased out by 2010 as per the Montreal protocol. These coaches are being converted with Eco-friendly HFC (R134a) refrigerants to comply the condition of Montreal Protocol.

- **Development of RMPU with HFC refrigerant**: At present HCFC (R-22) refrigerant is being used in Roof Mounted AC Package Unit. RMPU with Eco-friendly HFC refrigerant is being developed for air conditioning coaches to comply with the conditions of Monitorial Protocol by Government of India. As per the Protocol, HCFC (R-22) refrigerant is to be phased out by 2040.

- **Improvement in Ventilation in EMUs**: In Mumbai area, passengers feel uncomfortable during peak hours in EMUs due to super dense crush loading. Fresh air ventilation has been incorporated in AC DC EMUs as only circulating fans are not adequate.

- **CO/CO₂ controlled ventilation for EMUs**: In Suburban trains during peak rush hours passengers feel suffocation due to increase in concentration of CO₂. Ventilation system can be designed to provide fresh air after sensing CO₂ concentration.

- **Removal of harmful gases from exhaust of power car (for 20 cars)**: The use of fuel catalyst and catalytic converters has been undertaken to control air pollution from exhaust of power cars in Rajdhani/ Shatabdi Express trains. The trial of the above two system has been undertaken to evaluate its effectiveness and reducing the exhaust emission.

- **Development of Microprocessor Control for RMPUs**: Earlier RMPU controller was not having the feature to monitor the critical parameters and was also not energy efficient under varying ambient and loading conditions. Microprocessor based control panel for RMPUs has been developed, which is capable to monitor the temperature and humidity inside the coach, critical parameters such as High Pressure/ Low Pressure, voltage and current of the system, downloading the failure data along with the status of working of other equipment to overcome disadvantages.

- **Development of New Rolling Stock for Kolkata Metro**: Development of Kolkata Metro Rolling Stock for Tollygunj to Garia extension has been undertaken to improve the reliability of the equipments, passenger comfort, safety and incorporation of latest technology.

- **To reduce the minimum speed for full output for Train lighting Alternators existing 800 rpm to 600 rpm for 25 kW Brushless Alternator**: There was a complaint from NFR that in slow moving MG trains, generation of the coach is inadequate hence the batteries get discharged. Alternators with lower minimum speed for full output have been developed to meet their requirement.

- **Development of Low Maintenance Poly Propylene Co-Polymer (PPCP) battery for Electric Loco/ EMU**: This project was undertaken to achieve water topping interval of minimum 6 months in Electric Locos & EMUs batteries.

- **Upgradation of Train Simulation Software for EMU and MEMU applications**: This software will be used for simulating the EMU/ MEMU train
running for calculating typical run time and specific energy consumption with different input parameters with latest language.

- Development of High Horse Power Traction Motor with Roller Suspension Bearings for AC EMUs and MEMUs: The technology is based on Fuji design and class 200 insulation level. Roller suspension bearing is also incorporated in place of plain sleeve bearing, which is commonly used bearing in modern rolling stock traction motors. This will improve reliability, maintainability and will have more power, higher acceleration/ declaration.

- Development of High Capacity Low Noise Compressor for 3 phase EMUs: With the introduction of air spring and air dryer the duty cycle of compressors have increased requiring more maintenance and reduced reliability. Compressor is being developed to improve reliability and reduce maintenance periodicity, higher capacity and low noise.

- Development of High Capacity EP Contactor for EMU/ MEMU suitable for Higher Capacity Traction Motor: High capacity EP contactors are required to handle the additional load due to increase power of Fuji design Traction motor having higher power. Existing contactors are suitable to handle the load of the TM 4601 only.

- Development of Fuel Cell for Railway Crossings: Efforts are being made to develop Fuel cell as non-conventional energy source for electrification of manned level crossing gates and for other applications, where conventional power supply is not available nearby.

- Development of Solar Panels for Electrification of manned level power: Solar panels are under development as non-conventional energy source for electrification of manned level crossing gates and for other electrical applications and also as energy conservation measures.

- Development of 25 kV AC/1500 V DC, dual voltage microprocessor control IGBT based 3 phase propulsion system and equipments for Mumbai Suburban Services: This system is based on the IGBT technology, which is more reliable. It will have additional features such as “Passenger Information System” and “Ventilation system to wards passenger amenities”. Microprocessor based diagnostic and control system is for prompt action of driver in case of failures/ faults etc.

- High speed Electric Train set: The specification for high speed electric train set (160 km/h) is under preparation. This service is particularly suitable for carrying more passengers at faster speed between two major cities. The computer simulation has shown improvement of approx. more than 3 hours in New Delhi-Howrah section compared to present locos hauled trains.

Codes, Manuals and Standards: The directorate has contributed significantly for 77 specifications, 13 reports, 16 Special Maintenance Instructions and 16 Schedule of Technical Requirements along with several Modifications Sheets.
1. Existing EMU

2. MEMU Rake

3. New High Capacity Low Noise Compressor for AC EMUs

4. Roof Mounted AC Package Unit for LHB Design AC Coaches

5. Dual Voltage 3 phase AC-DC EMU

6. 25 kVA Underslung Inverter for SGAC Coaches
General

Metallurgical & Chemical Directorate came into existence as a wing of Research Directorate of RTRC/ RDSO in the year 1953 at Chittaranjan to support the research, development and standardisation activities. It was headed by a Joint Director (M&C) initially and it continued to function as a wing of Research Directorate till March 1967 after which it was elevated as an independent directorate with Director (M&C) as its head. The office and laboratories of M&C Directorate were shifted to its present location at Lucknow in a phased manner during the period 1967 to 1972. Since then, M&C Directorate is functioning at Lucknow and few additional facilities have also been added based on the advances taken place in the field of Material Science from time to time. During the year 1995, the post of Director (M&C) was re-designated as Executive Director (M&C).

Main activities being carried out by M&C Directorate are development of suitable metallic, non-metallic, polymeric, anti-corrosive coatings and lubricants. In addition, developmental work in respect of non-destructive testing of critical rolling stock and Permanent way components, re-conditioning of worn-out components, failure investigation of critical components and studies into fatigue and fracture behavior of materials is also carried out.

Laboratories

The main laboratories are as under:-

- **Non-Destructive Testing Lab**: In this laboratory, indigenous development of all ultrasonic testing equipments and standardised test procedure for various critical components e.g. rail, rail welds, axles, wheels, tyres etc. have been developed.
- **Non-Destructive Testing Training Centre**: It is one of the unique training centres of its kind in the country with a very high level of reputation and is regarded as centre for technical excellence. The centre has so far trained 5,000 Railway personnel in the field of ultrasonic examination to ensure safety of rolling stock and permanent way.
- **Sri C.G. Bashyam, Retd. Director (M&C) is remembered as the founder of non-destructive testing and its application on IR. Indigenous development of ultrasonic testing equipments took place under his able leadership and guidance.**
- **Fatigue and Fracture Mechanics Lab**: This laboratory has carried out pioneering work into the fatigue and fracture behavior of various Railway materials which has been helpful in design, standardisation and preventive maintenance. The work on wear resistance of various Railway components
carried out by this lab is praiseworthy.

- **Failure Investigation Lab:** This laboratory has carried out metallurgical failure investigation into a large number of Railway components involved in derailments, accidents and failures in service. Through its investigational work, it has been possible to significantly contribute towards development of remedial action to prevent recurrence. In addition, a number of materials, newer alloys and micro-alloyed steels have been evaluated for its implementation on IR.

- **Rubber and Plastic Lab:** With the introduction of polymers, this lab has been responsible for testing, evaluating and standardizing various products for their efficient utilization. Almost all the critical components e.g. GRSP, insulating liners, FRP components, elastomeric pads, buffer springs etc. have been developed as a result of work done in this Lab. This Lab has brought out a book titled ‘Rubber In Railways’ which has been widely appreciated.

- **Lubricant and Tribology:** This laboratory has significantly contributed towards development of high performance greases, loco crank case oils and various lubricants for machinery and plant. It is regarded as one of the most sophisticated laboratories for evaluation of fuels, greases and lubricants on IR. Currently, a project is underway to establish a full fledged Lab for Bio-Diesel testing and development.

- **Paint Testing Lab:** Indigenous development of high performance organic coatings, coach cleaning composition and corrosion behavior studies of various Railway materials are some of the significant contributions made by this laboratory.

**R&D Activities**

Main R&D activities carried out by

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*Sri A. Ramamurthy, Retd. CMT is the pioneer in the field of Research and Development of organic coatings and corrosion prevention in RDSO. Through his pioneering efforts, 13 paints were developed and patented.*

*Dr. S.P. Manik, Retd. Addl. Exec. Director (M&C) is regarded as the founder of Rubber, Plastics & Composite evaluation laboratory of the M&C Directorate. Entire development of Rubber, Plastic, Composite and Polymeric materials and its standardisation have taken place under his guidance.*

*Welding Research Section: Introduction of newer welding technology, selection of proper welding electrodes and development of weld reclamation procedures of critical components are some of the significant contribution made by this laboratory. In addition, the technology of Flash Butt welding, AT welding and gas pressure welding have been successfully developed and evaluated in this laboratory.*
M&C Directorate which has made significant impact on safety, reliability and quality of components are given below:-

1960-1969

- Introduction of ultrasonic examination of rails and axles utilizing imported equipments and standardisation of the test procedure;
- Development of weld reclamation procedure for worn out wheels, points and crossings for service life of 15 GMT;
- Introduction of submerged arc welding process of structural steel;
- Development of procedure for reclamation/reconditioning of axle oil, crank case oil, transformer oil etc.;
- Development of paints based on CNSL resin (13 patents were filed and patent rights granted).

1970-1979

- Indigenous development of ultrasonic equipment for detection of defects in rails and axles. Two sources developed resulting in complete import substitution of ultrasonic equipments as a result 100% equipments on IR are of indigenous origin.
- Establishment of Thermit Portion Plant for IR to achieve self-sufficiency in portion manufacture and rail welding.
- Development of weld reclamation techniques for wheel burn/ scabs on rails, tie tamping tools and loco components; Studies into fatigue properties of 52 kg 70 UTS rails, Carriage and Wagon axles.
- Studies into wear characteristics of wheel versus rail;
- Rationalization of roller bearing greases for locos, coaches and wagons.

1980-1989

- Development of memory based ultrasonic testing equipments for detection of defects in rail and axles;
- Development of short preheating welding technique (SKV) for Alumino-thermic welding of rails;
- Development of Flash Butt Welding technique of rails and standardisation of welding parameters;
- Studies into the fatigue properties of Structural steel, Corten steel and micro-alloyed rail steel;
- Development of superior performance grease for spherical roller bearing and cartridge roller bearing of rolling stock.

1990-1999

- Development of double rail testers with multi channel facilities for ultrasonic
examination of both rails simultaneously;
- Development of weld reclamation procedure for Co-Co bogies, gas inlet casings, central pivot pin, equalizer beams and bolster suspension hanger;
- Determination of fracture toughness of indigenously developed axle steel;
- Establishment of testing and evaluation facility for Rubber, Plastics, Polymers and Composites both thermosetting and thermoplastics materials for substitution of conventional metallic and non-metallic components;

2000-2006
- Development of Ultrasonic Testing Equipment for detection of gauge face corner defects in rails;
- Development of digital ultrasonic flaw detector indigenously for the first time;
- Development of dedicated ultrasonic testing equipment for detection of defects in AT weld;
- Development of 3-piece prefabricated mould for Alumino-thermic welding of rails in place of conventional 2-piece mould to eliminate defects in rail foot;
- Development of hard facing electrode for reconditioning of CMS crossings for enhanced service life of 25 and 35 GMT;
- Standardisation of MIG/ MAG welding filler wire for improved quality of welds;
- Studies in to effect of micro alloying on mechanical properties of rails;
- Development of high performance Epoxy/ PU paints and its standardisation;
- Development of on-line testing of wheels at Durgapur Steel Plant and standardisation of heat treatment for superior quality of wheels for loco and carriage.

Codes, Manuals and Specifications:
- Preparation of code of procedure for ultrasonic testing of different design and configuration of axles, armature shafts and other miscellaneous components was started by the directorate from the year 1970-71 to detect service defects i.e. fatigue cracks etc. during POH/ ROH schedule so that on line failure can be avoided. So far this directorate prepared 307 codes of procedure and circulated to POH/ ROH workshops of IR for ultrasonic testing of axles, armature shafts and other miscellaneous components.
- Polymer & Composite section: 208 specifications/ standards have been issued for the components of rubber, plastics, composites and allied materials by the directorate so far.
- Paint section: 20 standards have been framed by this section most of which are Epoxy cum Polyurethane based paints.

Sri K.C. Choudhuri, Retd. Director (M&C) is the founder of Metallurgical and Chemical Directorate who established entire testing facilities in M&C Directorate and was the prime mover for research, development, standardisation and investigational work during the period 1959 to 1973.
Quality Assurance Wings

General

RDSO has been rendering service to IR including Production Units since its inception for ensuring good quality of materials and products particularly for safety and critical items. Earlier the quality assurance functions were being done by the Design Directorates viz Track, B&S, Wagon, S&T, Electrical and M&C. The activities of quality assurance have been increasing year by year and have been found to be of vital importance to IR for good quality products. Keeping in view this aspect, a separate wing headed by a Sr. Executive Director with officers of different directorates was created in the year 2002 and has been working since then. Presently the wing has three Executive Directors, one each for Mechanical, Civil and S&T. The QA Wing is supported by Directors/ Jt. Directors/ Dy. Directors of these disciplines along with those of Electrical and M&C. Quality inspections are done by B&S Directorate for fabrication of open web girders and welded girders and by Electrical Loco Directorate for electrical items. In addition to the officers and staff posted at RDSO, Lucknow, several units are functioning at outstations. Cells for Railway Production Units and industries which look after liaison, inspection and development work are located at Bangalore, Bharatpur, Bhopal, Mumbai, Burnpur, Kolkata, Chittaranjan, Kapurthala, Jhansi, Chennai, Sahibabad, Bilai and New Delhi.

Main Activities

It is been carrying out the following main functions:-

- Vendor development and approval for generating sufficient sources for safety and critical items: The vendor approval includes capacity assessment, fresh registration renewal of registration, upgradation, downgradation/ delisting, reinstatement after downgradation/ delisting, change in name/ address of vendor and all activities related to quality control for the specified list of items.
- Quality audit of items and products including inspection of vendors and wagon manufacturers.
- Purchase inspection for critical and safety items such as concrete sleepers, critical track fittings, signal and telecom safety items, rolling stock items and also purchase inspection of such items where Railway and non-Railway organizations such as BALCO, CONCOR, Defence, DMRC, MRVC, RITES, RVNL etc. want them to be done by RDSO.

1. QA (Mechanical): Main functions:-

- Inspection of wagons;
- Inspection of specified safety and critical items for Railways as well as non-Railway parties: A total of 68 items (40 of wagon, 14 of carriage and 14 of loco) are inspected.
- Vendor development/ registration (multi-sourcing) of safety and critical items, as specified: A total of 122 items (12 of carriage, 47 of wagon, 13 of loco and 50 of M&C) are dealt by vendor approval.
- Issue of vendor list for all items dealt by Mechanical Directorate of RDSO;
- Quality audit of Railway workshops/
depots as assigned by Railway Board from time to time;
- Inspected items during 2004-05 (Indian Railways Year Book 2004-05, p-99) worth Rs. 1,249.71 crores – an increase of 9.1% in comparison to the last year and carried out 12 quality audits of Railway workshops.
- Earned Rs. 241.53 lacs as inspection charges for BLC, BOMN, BAST, BFAT, BAT wagons from CONCOR, Defence, DMRC and BALCO during 2004-05.

2. QA (Civil): Main functions:
- Development of concrete sleeper plants on IR and oversight inspection of these plants;
- Inspection of five identified critical safety track items viz CMS crossings, GFN liners, Polyethylene dowels, Grooved rubber sole plates and AT welding portions;
- Vendor development (multi-sourcing) and reassessment of vendors for safety and critical items: A total of 27 items for Track are dealt for vendor approval.
- Issue of approved vendor list for Track items dealt by RDSO and some items of Bridges & Structures;
- Quality audit of approved vendors and other activities related to quality of Track items;
- Assessment of production capacity of vendors;
- Quality checks at consignee end;
- Inspected during 2004-05 worth Rs. 107.82 crores (Indian Railways Year Book 2004-05, p-99) and carried out assessment of production capacity of 76 vendors (SGCI insert-18; GFN liners-44; and Glued joints-14);
- B&S Directorate during 2004-05 inspected 2557 t of open web girders and 2356 t of welded girders.

3. QA (S&T): Main functions:
- Purchase inspection of S&T items for Railways and non-Railways such (DMRC, RITES, IRCON, RVNL, RAILTEL and MRVC);
- Purchase inspection of specified safety and critical items of S&T;
- Vendor development of generating sufficient number of sources for Railways, for specified safety and critical items of S&T;
- Redressal of routine complaints in a specified time frame for consumer satisfaction;
- Inspected during 2004-05 (Indian Railways Year Book 2004-05, p-99) S&T items worth Rs. 761.20 crores and 38 fresh vendors were approved. Capacity-cum-capability cases of 45 vendors were finalised and technical audit of 76 firms conducted.

4. QA (Electrical): Main functions:
- In order to improve the reliability of traction motors manufactured at BHEL, Bhopal, a number of additional checks have been introduced in the year 2003-04 by RDSO at BHEL, Bhopal during inspection of these motors. As a result, the rejection rate at DLW of traction motors type TM4907 of BHEL has come down from 15% during 2002-03 to 2% during 2003-04. Similar quality checks are being done for other important items also.
- Items costing Rs. 241.87 crores were inspected during 2003-04.

Quality Assurance Wings of different directorates have been doing very useful quality assurance work for critical safety items leading to better quality of service.
Psycho Technical Directorate

General

Psycho-Technical Unit was set up in Railway Board in the year 1964. In 1970, it was transferred to RDSO as a unit of Traffic Wing. It was upgraded as a full directorate in 1989 and since then is headed by Director Psycho/ED/Psycho.

Main objective of the directorate is to increase job performance, job satisfaction and motivation of employees as well as prevention of accidents due to human lapses. In this perspective, the directorate is engaged in research studies on variables considered important for traffic safety so that phenomena of accidents causation could be understood. On the basis of information obtained through research, study programmes which aim to reduce accidents induced by human factors, are developed and executed.

Main activities of Psycho-Technical Directorate are as follows:-

- Scientific job analysis;
- Development and standardisation of aptitude tests;
- Estimation of training needs of employee’s and providing guidelines for development of training programmes;
- Research on problems related to organisational behaviours;
- Development and implementation of programmes for stress reduction; and
- Human engineering.

Laboratory

It has mainly two Labs:

1. **Psycho Technical Lab:** The Lab has various equipments for assessment of psycho-motor abilities and skills through computerised testing. Before deputing the drivers on prestigious trains (Rajdhani & Shatabdi), drivers have to undergo mandatory tests at RDSO. Only after qualifying these tests, they can be deputed on high speed trains. It has Computerised Driver’s Aptitude Test which assesses various critical attributes needed for safe train operations in the staff viz Depth Perception, Distribution Attention, Simple Reaction Time, Choice Reaction Time, Form Perception, Continuous Addition, Rail Sign, Visual Vigilance, Fatigue, Peripheral Vision, Visual Acuity, Night Vision, Glare Recovery. Other equipment based tests are Photo Electric Rotary Pursuit, Digital Flicker Fusion Test, Complex Reaction Time, Discriminative Reaction Time, Choice Reaction Time, Speed Anticipation Test and Visual Vigilance Test.
2. **Ergonomic Lab:** This Lab based on the state of the art technology has the facility of measurement and control of stress with the aid of biofeedback equipment, which assesses Galvanic Skin Resistance, Respiration, Temperature, Electro Mayo Graph and Pulse Rate. Alpha EEG equipment is used for monitoring and displaying an individual’s ongoing activities generated in his brain.

Biofeedback is a treatment technique in which people are trained to improve their health by using signals from their own bodies. Physical therapists use biofeedback to help stroke victims regain movement in paralyzed muscles. Psychologists use it to help tense and anxious clients learn to relax. Specialists in many different fields use biofeedback to help their patients cope with pain. For patients, the biofeedback machine acts as a kind of sixth sense which allows them to “see” or “hear” activity inside their bodies. One commonly used type of machine, for example, picks up electrical signals in the muscles. It translates these signals into a form which patients can detect. It triggers a flashing light bulb or activates a beeper every time muscles grow tenser. If patients want to relax tense muscles, they try to slow down the flashing or beeping. Biofeedback techniques that grew out of the early Lab procedures are now widely used to treat an ever-lengthening list of conditions.

**Main Activities**

The directorate has been instrumental in development and standardisation of behavioural intervention programmes and their implementation on the IR by playing a vital role in recruiting the right personnel for the operating categories. One of its kind in India, the directorate is continually working towards minimising human failure through processes like, aptitude testing and research studies on various issues related to organisational behaviour and Ergonomics.

The activities of the directorate have primarily focussed on selection of operating staff through aptitude testing, improving employees’ performance through job satisfaction and motivation resulting preventing accidents due to human failures. The occurrence of accidents is a phenomena of multiple dimension, such as failure of equipment, lapses of the personnel involved (human error) in train operation or combination of both. The role of human factor has been found very significant accounting 65 to 70% accidents. The main projects done are as under:-

- **Development of Computerised Aptitude Tests for High Speed Train Drivers:** In 2006, Psycho-Technical Directorate developed a computer based test package “CADAT” for the drivers who are deployed on trains running at a speed of 110 km/h and above. This test measures specific abilities related to the job of drivers, such as, reaction time, form perception, vigilance, speed anticipation and some selected attributes of personality. Testing process and calculation of results are fully automatic and the result gets generated as soon as the testing is over. Similar tests are administered in all advanced railway
systems abroad. The test was developed by RDSO in collaboration with an outside software agency. This test is finding application in screening of High Speed Train drivers of IR w.e.f. September 2006.

- **Periodic review of Aptitude tests:** As per the directives issued by Railway Board, aptitude tests are applicable in recruitment and promotion of Asstt. Station Masters, Asstt. Loco Pilots and Motormen. After every five years job analytic studies are taken in hand for these categories of staff and on the basis of this, validity of aptitude test battery is reaffirmed. The selection programmes are evolved according to the changes in railway working so that the efficiency of the test battery is maintained at accepted levels. At present a test battery is being developed for the selection of Asstt. Loco Pilots. In this regard more than ten psychological tests have been developed and now their reliability and validity is being determined.

- **Computerisation of Aptitude tests:** Railway Safety Review Committee (1999) recommended computerisation of psychological tests applicable on IR. In compliance of this recommendation, Railway Board had sent a team of officers to study the status of computerised tests on Advanced Railways system abroad. Keeping the recent trend of psychological testing in view, a computerised psychological test package has been imported from Austria.

  A research study is being initiated for the indigenous adaptation of this test package. After completion of it, there is a comprehensive plan for the computerization of entire aptitude testing on IR.

- **Techniques of Stress Management:** Ergonomic Lab of the directorate has completed a series of projects on causes and control of stress. A number of workshops have been organized with the help of Premier Yoga Institutes of the country, which aim at helping the employees towards better adjustment with their job. The Ergonomic Lab has facilities for measuring various physiological parameters through which level of stress can be

  ![Inauguration of Stress Management Workshop by Sri A.K. Rao, DG, RDSO](image)

  ![Vienna Test System for Computerised Testing](image)

  ![Yoga & Meditation Exercises in Stress Management Workshop](image)
identified and biofeedback offered to employees. The directorate has planned five workshops on Stress Management during the year 2006-07.

**Specific Contributions:**

- During the past years, Psycho-Technical Directorate has completed many projects on job analysis of Asstt. Station Masters, Asstt Loco Pilots and Motormen. Job profiles have been developed on the basis of research studies, which exhibit characteristic of personalities and required abilities for successful job performance of these employees. On the basis of these job profiles, the directorate has prepared psychological test programmes for several categories of employees, which are presently finding application on IR.

- Provided technical consultancy in the selection of Train Operators/Station Controllers, Asstt. Station Masters and Asstt. Drivers to DMRC and KRCL;

- Extensive psychological case studies of staff involved in accidents have been conducted by the directorate and important information has been made available to rail administration for improving safety.

- A package has been prepared for application on the Railways to increase the vigilant behaviour of drivers by training and counselling.

- Experimental studies were conducted on problems related to hours of work, noise, speed of train, night shift working and matters related to human-machine interface etc., which facilitate in decision making of rail administration.

- Research study was conducted on competency based placement and counselling of front line commercial staff. On this basis a package for selection and training of On-Board employees of Rajdhani/ Shatabdi trains was developed.

**Consultancy**

The directorate has been rendering services particularly to the IR and as well as to the other organizations such as Konkan Railways, Delhi Metro Rail Corporation, Hindustan Aeronautics Ltd. and engineering colleges.


General

Research Directorate came into existence at Lucknow from RTRC days and was looking after all the research and testing work of IR being done by all disciplines viz Track, Bridges, Geotechnical, Track Monitoring, Oscillations and Dynamometer, Signalling and Telecommunication etc. It had a sub-centre at Lonavla for Civil Research particularly Soil Engineering and Concrete Technology. Soon after formation of RDSO, Lonavla section was shifted to RDSO campus at Lucknow. Originally the directorate contained many Labs and field test units equipped with TRCs, Oscillograph, Dynamometer car etc. with the following functions:

- **Electronics Lab:** It was providing full instrumentation support with qualified engineers for conducting various trials for improvement of tracks, vehicles and for running high-speed trains. The Lab has been also developing various types of transducers required for trials and testing such as LVDTs, Accelerometers, Pressure Cells etc. In all field trials apart from the staff and officers of Civil or Mechanical Wing an instrumentation team with its equipments have been providing instrumentation support for these trials.

- **Vacuum Brake Lab:** Earlier there was a vacuum brake Lab for bringing about improvements in the vacuum brake system then prevalent on IR. This Lab could simulate field conditions for long freight trains. With the improvement in braking techniques and introduction of air brakes on IR the utility of the Lab was lost and has since been closed.

- **Air Brake Lab:** The Lab was setup in early seventies and has been equipped with facilities for simulating operation of air brakes on freight trains up to 92 wagons with locos and passenger trains up to 30 coaches with twin pipe brake system.

- **Brake Dynamometer Lab:** It has facilities to develop and test brake friction materials for locos, coaches and wagons.

- **Fatigue Testing Lab:** It was modernized with latest equipment in seventies and is used for testing prototype loco and rolling stock bogies, springs and other Railway equipments subjected to stress and fatigue so as to ascertain their service life.

- **Impact Lab:** This is located near the RDSO yard and is used for study of impact forces on Railway vehicles by simulation.

- **B&S Lab:** The Lab has been in existence from the beginning of RDSO at first for concrete technology and study of construction materials along with non-destructive testing facilities for testing of bridges and structures. Now the Lab has been modernized and is being used for conducting field trials and investigations including non-destructive testing of bridges and structures.

- **Microprocessor Applications Engineering Center (MAEC):** It was setup in November 1985 with the help of DOE. It undertook development of Microprocessor based systems i.e. Microprocessor Based TRC, OMS and Microprocessor based system for control of air-conditioning of AC coaches. MAEC also provided training to officers/staff on computer working and various languages.

- The directorate was also equipped with seven TRCs for measurement of track parameters on IR for better maintenance of tracks and improvement of tracks for
running high speed trains and oscillograph and dynamometer cars for oscillation trials of rolling stock for clearing them for high speeds.

The Research Directorate was reorganized in April 1986 and B&S Lab was transferred to B&S Directorate, Track Machines and Track Lab were transferred to newly created Track Machines and Monitoring Directorate and oscillation trials etc. were carved out to a newly created Testing Directorate.

Since 1986, the Research Directorate has been providing quality instrumentation required for conducting trials by different directorates of RDSO and Zonal Railways. After reorganization of the directorate in 1992 various R&D projects of multidisciplinary nature are being done by the directorate. The directorate is now equipped with Electronics Lab, VCF Lab, and MAEC Lab.

(i) Electronics Lab is undertaking development of transducers required for conducting trials and arranging instrumentation for conducting various trials. The Lab has undertaken the development of OMS and also doing calibration of transducers and repair of various type of recorder.

(ii) VCF Lab has been doing vehicle dynamic studies, determination of vehicle suspension parameter and development of measuring wheel technology. The following are some of the major activities:-

- Dynamic stress measurement of rolling stocks;
- Dynamic rating of side buffers & CBC pads in buff;
- Assessment of maximum permissible speeds for rolling stock;
- Static stress measurement;
- Measurement of impact load on rails due to wheel flats;
- Assessment of natural frequencies under rigid and flexible body modes.

(iii) Development of Wheel Impact Load Detector has been undertaken by MAEC Lab.

The directorate has been arranging apex level meetings of Governing Council (GCM) and Central Board of Railway Research (CBRR) and coordinating with foreign institutions like UIC, AAR and TTCI. Now, under IR modernization plan new projects have been taken up under Technology Mission on Railway Safety (TMRS). Research Directorate is coordinating for 12 projects of TMRS.

R&D Activities

The various R&D activities performed by the directorate in past are as under: -

Developments by Electronics Lab:

- **Accelerometers**: Developed accelerometers based on vibrations in fifties and sixties. In these types of Accelerometers, a cantilever formed by two strips is fixed at one end and a mass is fixed on other end of the cantilever. Four strain gauges are fixed on both surfaces of two cantilever strips. These strain gauges form the arms of a Wheatstone bridge to convert vibrations into electrical signal. The electrical signal is directly proportional to the vibrations. Silicon oil is used for damping of strain gauge cantilever assembly. The Accelerometers developed by Electronics Lab can measure vibration level of 1 g to 10 g.

- **Strain gauge based load Cell**: Developed a Strain gauge based Load Cell type Transducer in sixties. Load Cell consists of a solid piece of steel stud on which strain gauge is fixed. It converts force into a change of resistance in four arms of
Wheatstone bridge due to strain. This transducer is used to measure direct compressive or tensile loads. It is commonly used to measure the force between the axle, box and the bogie frame. This kind of transducers can measure load up to 2 t.

- **Linear variable Differential Transformer or Displacement Transducer (LVDT):** Electronics Lab developed LVDT Transducers in sixties. It consists of a primary winding and two secondary windings differentially connected. They are wound over a hollow mandrel (coil former, bobbin). It is usually of a nonmagnetic and insulating material. A ferromagnetic core is attached to the transducer-sensing shaft. The core slides freely within the hollow portion of the bobbin. The core is made from high permeability ferromagnetic alloy and has the shape of a rod or cylinder. An AC excitation voltage is applied across the primary winding and the variable core varies the coupling between and secondary windings. A differential voltage is obtained directly proportional to displacement of core. Two types of LVDT transducers to measure displacements of ± 4 cm & ± 8 cm were developed. Testing, GE, TM and B&S Directorates have been using these LVDTs for measurement of displacement.

- **Soil pressure load Cell:** Electronics Lab developed a Soil pressure load Cell for measurement of soil pressure by GE Directorate in seventies. It works on principle of sonometer, a steel wire is fixed between two posts on a diaphragm. Tension in the wire is adjusted to produce the frequencies corresponding to pressure exerted by the soil. When the pressure is exerted by soil, a corresponding voltage is induced in the magnetic coil, which is directly proportional to the pressure exerted by the soil.

- **Wheel Flange Lubricator:** Wheel flange Lubricator was developed during 1990-95 to reduce wheel tractive effort and rail wear besides reducing energy consumption. The application of a small quantity of grease at regular intervals on the flanges of locomotive wheel results in reduction in tractive effort and consequent savings in the fuel. An additional benefit of lubrication is to increase the life of wheel and rails as a result of lower wear and tear. This is achieved with the help of Delivery Valve, which delivers a measured quantity of grease mixed with compressed air. The mixture is spread on the wheel flange through a nozzle mounted on the bogie frame. Grease under pressure is continuously available at the Delivery Valve. The electromagnetic valve is activated by 72 V DC supply on diesel loco and 110 V DC supply on electric loco.

- **Wheel Flat Detector System:** The presence of wheel flats in the rolling stock results in uneven riding and heavy dynamic augment of the wheel loads due to pounding of wheel flats on rail table causing damage to track as well as to rolling stock. Timely detection and detachment of vehicles with wheel flats shall help the IR to minimize the incidence of rail fractures and failure of wagon components. For this purpose, it was necessary to develop a suitable system for detection of flat wheels. A Wheel Flat Detector System was developed at MAEC Lab.

- **Microprocessor control system for air-conditioning of AC Coaches:** In existing AC coaches the air-conditioning control is done by thermostats and control of compressors and heaters. As all these controls were done manually hence a Microprocessor based control system for control of cooling and heating of AC coaches was developed by MAEC Lab for better control of Air-conditioning of AC coaches and provides comfort to passengers.

- **OHE Car:** Development of OHE car
was undertaken during nineties to monitor on line stagger and height of contact wire and also the abnormalities like kinks. Instrumentation provided in the car collects the data and after suitable conditioning and multiplexing transmits it to the coach body for conversion and analysis. Stagger is defined as the distance of contact wire from the pantograph axis measured transverse to the track. OHE recording-cum-test car is used for measuring bow mounted at the pentopan with 45 inductive proximity detectors whose successive axis are spaced 20 mm apart.

Projects in progress:

- Development of Track Side Bogie Monitoring System: The project envisages development of a system installed along the track for detecting faults in bogies of rolling stock. This will include development of appropriate instrumentation and signal processing strategy for detecting various types of faults in bogies. It will enable online monitoring of condition of bogies. The instrumentation will also include sensors for detection of components of the rolling stock which may fall on the track due to failure of fastening and which may cause derailment.

- Development of Derailment Detection Devices: The project envisages development of On-Board equipment for sensing derailment of rolling stock. This will include development of appropriate instrumentation and signal processing strategy and its integration with the existing brake system for various types of Rolling Stock. This will prevent derailment caused due to mounting of wheels and actuate emergency brakes. It will also reduce drag distance and damage to unavoidable derailments/accidents due to sudden causes of sabotage, rail fractures, bridge collapse etc.

- Sensors for Detecting Hot Box, Hot Wheels: The project envisages development of detection system for identifying axel-boxes running hot due to bearing failure and wheels having abnormally high temperatures due to brake binding. This will include use of sensors having fast response time so as to identify hot boxes and hot wheels on trains running up to 200 km/h speed besides development of appropriate instrumentation and signal processing.

- Development of Wheel Impact Load Detector (WILD): Wheel Impact Load Detector (WILD) has been developed jointly by RDSO and IIT, Kanpur. This system provides audio-visual signal to the train operating staff in the event of passing of an abnormal wheel having higher impact load due to wheel flats/defects, which may cause...
damage to the track as well as rolling stocks. The WILD system automatically detects the wheels having higher impact load & round the clock automated recording has also been started. In this system, 12 circuits of Rosette strain gauges are fixed on the web of rail between sleeper cribs on each rail for covering two revolutions of most standard diameter wheels to ensure 100% detection of the wheels having abnormal signatures. As a train approaches, the leading wheel-set triggers the advance sensor to start the system. After passing of the train, the recorded data is automatically analyzed and down loaded through telephone link to control room computer.

- Development of Oscillation Monitoring system:
  
  a. Development of Micro Controller Based OMS: Micro Controller based OMS has been developed by M/s. System Aids, Bangalore in consultation with RDSO. After approval by RDSO, Railway Board has nominated Eastern and Southern Railway for placement of orders on the firm. The firm has supplied 7 nos. of OMS against trial orders of Eastern, Southern and South Central Railway.

  b. Development of PC Based OMS: PC based OMS system has been developed by M/s System Aids, Bangalore in consultation with RDSO. The system is based on VC++ software. After the successful Lab and field trials, the OMS was approved by RDSO. Railway Board had nominated WR for placement of trial order. WR has carried out extensive field trial and OMS has been found working satisfactory.

  c. Development of Embedded Processor Based OMS: RDSO signed a MoU with M/s. CSIO, Chandigarh for development of OMS based on state-of-the-art technology of Microprocessor Architecture. The prototype OMS has been developed and approved by RDSO. During the development and testing stages, personnel of the user department from Northern Railway were actively associated and the suggestions given by them were incorporated in the system design.

**Technology Mission For Railway Safety:**

_Hon’ble Prime Minister of India Sri Atal Bihari Vajpayee during the Independence Day speech made on 15th August 2003, announced that:-_

“A Technology Mission for Railway Safety will be set up to comprehensively address safety-related issues in Indian Railways. This will be done in collaboration with the Department of Science & Technology, IIT/Kanpur and a consortium of private sector companies.”

Accordingly ‘Technology Mission for Railway Safety’ was set up.
Mission Goals:

- To develop and adopt state-of-the-art safety and control technologies defined by needs related to Indian conditions. The mission will implement projects aimed at achieving higher throughput, lower cost of transmission and safer train movement.
- To encourage and initiate R&D activities pertinent to IR in academic institutions and laboratories and establish convergence and synergy among them.
- To evolve and establish the academia-research institution-industry consortium approach as a viable and vibrant mission mode of research and development.
- To disseminate technologies through participatory approach to other application areas.

Mission Approach

A trident consortium comprising of IIT/ Kanpur, RDSO/ Lucknow and industry is formed. Such a consortium is essential for effective definition and implementation of projects.

The constituents of the consortium are collaborating to bring expertise and are sharing responsibilities. RDSO is expected to bring domain knowledge and experience to articulate problems and conceptualize projects. Academic institutions like IITs are contributing towards problem analysis, design synthesis and prototype development; the industry is expected to provide inputs relevant for adoption of technology and its commercialization.

In this regard the first meeting of the possible consortium was held at IIT Kanpur on 25th August 2003. The participants in this meeting included Ministry of Railways/ New Delhi, RDSO/ Lucknow, CSIO/ Chandigarh, TCS/ Bangalore, BESCO/ Kolkata, BHEL/ Hyderabad, New Delhi, Jhansi and Haridwar, BEL/ Bangalore, IIT/ Delhi, IIT/ Roorkee and IIT/ Kanpur.

The meeting was followed by further discussions on the technical and administrative scope of the proposal between the Director General, RDSO/ Lucknow, Senior Officials from the Ministry of Railways/ New Delhi and the Director, IIT/ Kanpur, on September 9, 2003. Further meeting took place between RDSO, Lucknow and IIT, Kanpur on September 15, 2003 and October 3, 2003 to define the framework of various research and development programs to be undertaken by the mission. Inputs were also received on many issues from the various researchers who participated in the meeting of August 25, 2003. The first version of the proposal was developed after these discussions.

The work is going on for 12 projects at the cost of Rs. 24 crores with approved funding as follows:-

- Ministry of HRD : 50%
- Ministry of Railways : 30%
- Ministry of Industries : 20%

Projects

The projects sanctioned by the Board figured in the Corporate Safety Plan and are important from the safety point of view as is evident from the description of each project and how it is going to deliver to the IR as detailed below:-

- **Trackside Bogie Monitoring System:** This project envisages development of a system to help identify bogies having worn/deficient parts causing abnormal running. This will prevent accidents due to failure of bogies of rolling stock.
- **Derailment detection devices:** This is to sense the abnormal increase in acceleration levels due to derailment conditions of the vehicle. This will prevent derailment and reduce drag distance in case of derailments due to abnormality in rail-wheel interaction.
- **Sensors for detecting Hot Box/ Hot Wheel:** This project is to identify bearing failures and cases of brake binding which cause abnormal rise of temperature. Accidents due to hot boxes and wheels can be prevented.

- **On-board Diagnostics:** This project will identify problems on the locos to take appropriate maintenance action and ensure enhanced safety of loco. This will be done by on-line real-time monitoring of vital loco components and communicating them to control, loco shed etc.

- **Wheels and Axles of Improved Metallurgy:** The project envisages developing steel of improved metallurgy for wheels and axles for safety, reliability and enhanced carrying capacity without altering design parameters substantially. This will give longer life of wheels and also failures will be prevented.

- **Measuring wheel:** This will be used to monitor the forces at the rail/wheel interface to evaluate the riding performance of the vehicle. This is an important equipment for accessing rail wheel interaction forces of rolling stock.

- **Environmental Friendly Coach Toilet Discharge System:** The project involves development of design for new type of toilet system which shall adhere to the norms of pollution control and help Railways in keeping the track and its surroundings clean and hygienic, besides preventing corrosion of rails and track fittings. This will also prevent rail corrosion and improve track failures.

- **Corrosion Prevention of Rails:** Corrosion of rail foot results into loss of rail section & rail fractures. The project aims to tackle the problem of corrosion of rails, especially under the liner location on rail foot and at weld collars and to prevent jamming of leg of elastic rail clips inside the insert. This will improve track failures.

- **Improved Rail Fastenings:** Elastic fastenings are used to hold rails with sleepers. The legs of Elastic Rail Clips (ERCs) are fixed in the inserts of concrete sleepers as fixing arrangement. The loss of toe load takes place due to fatigue of ERCs, crushing/damage/shifting of grooved rubber pads and corrosion/breakage of liners. These fittings are also sabotage prone. The above shortcomings are to be overcome in this project. Longer life will be possible and also improvement in failures.

- **Rail Flaw Detection Instrumentation:** The rail flaw detectors in use are unable to scan entire rail cross-section. It is also does not have the capability of recording the events. Therefore, an efficient detection system with data logger is required to be developed. Managing rail flaw will be very systematic and will improve safety on this account.

- **Satellite Imaging for Rail Navigation:** This will provide an effective system for monitoring location and speed of trains through combination of GPS, GSM and/or RF tags and to disseminate the information to passenger through web, display boards (at stations & inside the train) etc. Besides this, it will be a vital link to the “Derailment Detection Devices” and will communicate with control server from the derailment devices.

- **Fog Vision Instrumentation:** This will enable to provide adequate visibility to the driver of loco during acute foggy conditions to enable him to run train at higher speeds. This is an alternative to vision in fog conditions.

**Present position**

Technology mission for Railway Safety is progressing well and nine meetings of MICC have been held so far. The selection of industrial partners has been mostly finalised and some MOUs have also been signed. This Technology Mission for Railway safety is of vital importance to IR for improving safety.
Traffic Directorate

General

Traffic Directorate started functioning headed by a Jt. Director in 1966 under the administrative control of Director/Research. Subsequently, it was made an independent directorate headed by Director (Traffic)/Executive Director (Traffic) since August 1973.

The main work of the directorate involves liaison with other directorates of RDSO in respect of development of designs prepared by RDSO, conducting studies pertaining to traffic and commercial, coordination with research studies from very beginning which have bearing on line capacity and throughput. Presently the work undertaken by the Traffic Directorate is in the field of railway safety, line capacity enhancement, increase in throughput, tail lamp, banner flag and technical advice on safety matters.

The directorate acts as the nodal agency for handling matters connected with safety of train operations wherever advisory opinion of RDSO is called for by Railway Board/Commissioners of Railway Safety/Commission of Enquiry into railway accidents.

This directorate also conducts computer simulation studies for calculation of intersectional running times besides evaluating the repercussions of changes in various parameters of train operations and their effect on running time.

R&D Activities

The important contributions are as under:-

1966-70
- Report for the 9th session of the Railway Sub-Committee of the Inland Transport and communications Division;
- Study Regarding Documentation work in Marshalling Yard;
- Study on High Speed MG service between Delhi and Ahmedabad.

1971-80
- Study on high speed 4-wheeler covered wagon;
- Case for research into the problem of midsection derailment of goods trains on MG;
- Study on volumetric capacity of BG covered 4-wheeler Wagon (CRT type);
- Study on Rajdhani Express (New Delhi-Howrah) – an economic appraisal;
- Study project on application of information processing and scientific management tech. to the operation of railway transport;
- Study project on historical development of mechanisation of marshalling yard;
- Project on coal movement in self discharging (Hopper) BOX and BOXN wagons from Singrauli coal fields to Obra;
- Study for development and standardisation of items to form personal store of guard;
- Study on Introduction of light weight container (guard box);
Development of new formats of forwarding note, railway receipts etc.;

Study Report on suitable design, need and economics of new 4 wheeled open wagon;

Development report on battery operated hand signal lamps.

1981-90

Study report on standardisation and use of bold letters in suburban passengers tickets;

A study on breath analyzer equipment for the IR;

A study on rechargeable battery operated portable electric tail lamp;

Study report on brief appraisal of economics of moving coal in self discharge and BOXN wagons;

Foreseeable development of the demand of passengers and freight transport;

Development of suitable material and methods for sealing of door;

Maximum permissible speed over high speed turn outs;

Study on mechanisation of parcel handling at Lucknow station;

Development of a standardised layout for booking counters/ windows;

Comparative position of the proposed new colour light signalling with the existing MAACL for high speed loop;

Small handy box for train crew with newly developed/ modernized equipments;

Study on high speed turn outs – A cost benefit analysis;

Study for measures for improving distance visibility of colour light signals and consequently operational efficiency in train running;

Feasibility study of running guardless freight trains with use of rear end monitoring device ‘Charlie’;

Study on heavy haul operation on IR;

Traffic projection on MG with particular reference to transshipment and mechanisation of transshipment facilities for higher throughput;

Study to access possible advantages by increasing maximum operatable speeds of BOXN and all other freight trains.

1991-2000

New signaling scheme for high speed turn outs for better speeds;

Assessment of possible improvement in average speed of freight trains by replacement of loco hauled all stopping passenger trains with EMU trains;

Augmentation of throughput on Talcher-Paradeep section of SER;

Increase average speed of trains on Tata-Durg section;

Feasibility study of reducing journey time on Mumbai-Pune section;

Trial run of air brake coaching stock to determine intersectional running time based on which the running time of few important trains was reduced between New Delhi-Chennai;

Techno-Economic Feasibility Study for rationalization of movement of parcels traffic (ASR-HWH Route via Lucknow & Patna for streamlining operations of parcels on IR).
2001-06

- Feasibility study of reduction in journey time of New Delhi-Lucknow Shatabdi Express-with effect from 29.5.2001 based on which running time has been reduced by 15 minutes in both Up/ Dn. directions;
- Increasing throughput on Hospet-Bellary-Chennai Harbour Section by introduction of higher axle load wagons (Mission-14);
- Identification of technical inputs for enhancement of line capacity (Mission-18);
- Review of the Gate Working Instructions was done and revised working instructions issued in 2002;
- Study of powering of freight trains on graded sections was conducted in association with Track, Motive Power and Electric Loco Directorates and completed in 2002;
- Report on mechanization of parcels handling at Ludhiana & Lucknow stations;
- Specifications for LED based Flashing Hand Signal Lamp and Tail Lamp have been finalized in association with Signal Directorate;
- Feasibility study of reduction in journey time of Mail/ Express/ Passenger trains in GKP-BBK-LKO/LJN section;
- Framing of specifications for fuel cell sensor based alcohol breath analyser;
- Standardisation of wooden wedges for use in coaching and goods trains working on graded and Ghat sections;
- Guidelines for providing Booking Clerks at roadside stations;
- Replacement of existing Guard’s Line box with Light weight container;
- Feasibility study of reduction in journey time of Mail/Express trains between BSB-LKO section of NR;
- Increasing throughput in GZB-DLI-UMB-LDH and BSL-NGP-KGP sections.
Architecture Directorate

Architecture wing had been working since Central Standards Office days at Simla under Chief Design Engineer (Civil). After formation of RDSO, Sri N.B. Shroff was the Joint Director (Architecture). The directorate was shifted to RDSO, Lucknow in early sixties and the post of Joint Director was upgraded to Additional Director/ Directors level and functioned as a separate directorate of RDSO.

The designs of important and major buildings were prepared by the RDSO for which Architecture Directorate was working in close coordination with B&S Directorate. The designs were made on modern and functional lines keeping in view aesthetic values, economy and utility. Study models, interior features and prospective were also prepared for major works. Liaison was kept during construction phase to ensure that the work is executed according to the plans without bottlenecks. It has done commendable work during the period of its existence and has provided good architecture features to hundreds of important buildings. It has designed all the buildings of RDSO including Annexe-I and Annexe-II. Jaipur station building and Churchgate station building-cum-office complex as designed by the Architecture Directorate are given below:-

Jaipur station building is an example of harmonious blending of functional design with economy and aesthetic appeal. The eight storey Churchgate station building-cum-office complex combines passenger facilities and office accommodation. A spacious concourse ensures free circulation and quick clearance of heavy suburban passenger traffic while the upper floors provide 215,000 ft² floor area for the offices.

The Architecture Directorate was closed in 1986 and its officers and staff were absorbed in other directorates of RDSO and Zonal Railways etc. as it was felt by the then Honorable Minister of States for Railways, Sri Madhav Rao Scindia, that now the
architecture field has become too specialized and a lot of good consulting architecture firms have come up in the country and it would be better to utilize their services on consultancy basis as per the local requirements of the Railways and Production Units.

The contribution of the Architecture Directorate during three decades of its existence as part of the RDSO has been very useful to IR and hundreds of service and residential buildings designed by the architects of this directorate are scattered over the country stand testimony to it.
General

Bridges & Floods (B&F) Directorate was created in accordance with the recommendations of the committee set-up by the Ministry of Railways under the chairmanship of Dr. A.N.Khosla for investigating and reviewing the methods of estimating the maximum flood discharge from catchment areas in order to determine the waterway and other connection factors required for the design of bridges in the year 1960 under RDSO. Sri V.P.Riberio was the first Director (B&F) with headquarters in Baroda House, New Delhi. The directorate was subsequently shifted to RDSO at Lucknow and from mid-sixties the post of Director was changed to the post of Jt. Director (B&F). The B&F Directorate became a wing of Research Directorate of RDSO and continued as such till reorganization of Research Directorate in 1986 and then the post of Jt. Director (B&F) along with his team has been working under Director Standards (B&S).

Along with the special cell created at RDSO, cells were created in Center Water Commission and India Meteorological Department for implementing the recommendations of the committee headed by Dr. A.N.Khosla. The Ministry of Transport have participated in the implementation programme of the hydro-meteorological data collection and studies primarily aimed at development of methods for estimation of design discharges with frequency concepts. These studies have been very useful to IR as well as others.

R&D Activities:

- In pursuance of the Khosla Committee’s recommendations, the RDSO collected hydro-meteorological data from 360 catchment sites after dividing the country into seven zones and 26 sub-zones for a period spread over three decades from sixties to late eighties. Collection of reliable data for a period of about three decades for 360 catchments spread over the entire country is a very difficult task and requires lot of perseverance, frequent inspections and dialogues with Zonal Railways and field units. It was due to the sincere and hard work of the B&F Cell who have managed to get reliable data. Hydro-meteorological data was also collected from 45 sites by Ministry of Transport.
- This data has been analysed by Central Water Commission and finalised by Flood Estimation, Planning and Coordination Committee (FEPCC) comprising of Ministry of Railways (RDSO), Ministry of Surface Transport (MOT), Central Water Commission (CWC), and India Meteorological Department (IMD). Synthetic unit hydrograph relations have been developed for most of the sub-zones which practically cover the entire IR. In addition simplified correlations have been obtained for 16 sub-zones which enable to find out design discharge of 50 year return period without much computations.
- RDSO developed during late eighties improved rational formula in which the intensity of rainfall for specific return period is linked with the time of concentration for
catchment up to 25 km² area. The run-off coefficient is based on the soil, type and nature of catchment apart from the nature and extent of rainfall. This formula enables to calculate design discharge for bridges with small catchments in rational way and is being used on IR.

- The collection and analysis of the data has enabled the Railways to compute design discharges based on return period concept which has also been incorporated in the IRS Substructure Code and 50 years return period has been specified, in general, for bridges. RDSO has also compiled a ‘Handbook for Estimation of Design Discharge for Railway Bridges’ as Technical Monograph No. 50 in August 1990 which was prepared by the author and Sri P.B. Sinha.

- The B&F Directorate had also done study for scour around bridge piers in alluvial regions by collecting field data from NR, NER and NFR. An equation based on multi regression analysis has been developed correlating the depth of scour to discharge and silt factor.

- The directorate has been providing consultancy to various Railways regarding River Training Works, Estimation of Flood Discharge and waterways for existing and proposed bridges.

The directorate has served well the purpose for which it was created and has provided valuable data and design parameters including Design Discharge Handbook. Further requirements since mid-nineties are being looked after by the existing B&S Directorate.

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The work of B&F Directorate has been a teamwork of RDSO. However, Sri S.Thirumalai who retired as DDS (B&F), Sri P.B.Sinha who retired as ADE (B&F) need special mention. They have not only ensured proper collection of field data but have taken lot of efforts for analyzing it and coming forward with rational method for design discharge for catchments up to 25 km². They have also taken lot of pains in compilation of Technical Monograph No. 50 in 1990.
Computer Wing

General

The Computer Wing has glorious tradition of dissemination of knowledge and creation of productivity enhancement tools since the inception of the center in the year 1988. Sri V. P. Ojha was the first head of Computer Directorate. It worked as a full fledged Directorate from 1988 to 1999. Thereafter it was working as a wing attached to Research Directorate from 1999 to 2004 and is now with the Carriage Directorate.

Its main objectives have been to provide computer facilities to RDSO along with design softwares and provide training courses to users. In the early stages of its existence a large number of courses used to be conducted by this directorate for familiarization and dissemination of computer culture and impart training for special design softwares.

Facilities

It has following main facilities:-

- **Computer Aided Design:** 3D modelling and Engineering Analysis (Structural Analysis, Thermal Analysis, Fatigue, Electromagnetic Analysis, CFD etc.) software are loaded on server which is connected on LAN to 4 number of high end design workstations and 22 Intel design workstations. These systems are being utilised by various directorates for modelling and analysis of their designs.

- **Vehicle Dynamics System:** Computer Wing houses seven workstations for carrying out Vehicle Dynamics simulations. The softwares being used are ADAMSRAIL and NUCARS. The facility is used for simulation of coaches, wagons and locomotives.

- **Crashworthy Design System:** A 4 Node dual processor Xeon Server with two Xeon workstations have recently been installed for developing crashworthy designs of railway vehicles. The system has LS-Dyna software for non-linear crash simulation and True Grid software for modeling and mesh generation.
• **Mini Computer:** ORIGIN 200 along with 16 terminals distributed in Finance, Accounts and Computer Wing is used basically for financial and establishment related applications.

• **Peripherals:** Computer Wing has 2 A0 Size Colour Plotters, 2 number 132 column Line Matrix Printers, one A3 size colour Laser Printer and one A0 Size Scanner.

  All the above systems are provided electrical power supply through 100 KVA UPS to ensure uninterrupted power.

**Human Resource Development**

Regular familiarization courses are held on softwares e.g. Windows, Auto-CAD, MS-Word, MS-Access, MS-Excel, MS-Power Point & Hindi Kunjiyan along with hands-on training. Other courses in Oracle etc. are done occasionally as per requirement.

**Computer Library**

Computer Wing houses a number of original softwares and about 2000 books related to computer in its own library.
Annexure-I

Ministry of Railways

No. E53RB7/10/2(RBI) New Delhi, 7th March, 1957

To,

1. The Director,
   Railway Testing & Research Centre,
   Alambagh, LUCKNOW.

2. The Chief Design Engineer (In-Charge),
   Central Standards Office,
   NEW DELHI.


The Board have had under consideration the question of placing all the work connected with Research, Design and Standardisation under one organization. It has now been decided that the Central Standards Office for Railways and the Railway Testing and Research Centre should be merged into one organization (R.D.S.O. in brief). The new organization will be headed by an officer of the rank and pay of a General Manager and designated as Director-General.

2. The Central Board of Railway Research which is responsible for directing and co-coordinating research on Railways and securing co-operation of other institutions such as National Laboratories will also be re-constituted and will now consist of the following:-

   (i) Chairman, Railway Board;
   (ii) Member (Engineering), Railway Board;
   (iii) Two representatives to be nominated by the Council of Scientific and Industrial Research; &
   (iv) Director-General of Research, Design and Standardisation Organisation as Secretary.

3. The Director-General will have under him three Directors in charge respectively of:-

   (i) Civil Engineering Standardisation;
   (ii) Mechanical Engineering Standardisation; &
   (iii) Research.

   The Director, Civil Engineering (Standardisation) will be responsible for all the work that is done at present in the Civil Engineering and Architectural Sections of the Central Standards Office, and the Director, Mechanical Engineering (Standardisation) will be
responsible for the work of the Locomotive, Carriage and Wagon and Electrical sections of the Central Standards office.

4. The sanction of the Board is hereby accorded to the creation of the following permanent new posts. These will be in addition to the posts which already exist in the Central Standards Office and the Research & Testing Centre at Lucknow including the Sub-Centre at Chittaranjan and Lonavla and which will be integrated into the new composite organization with altered designations where necessary.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Designation</th>
<th>No. of posts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Director-General of Research, Designs and Standardisation</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Directors, Standardisation Civil &amp; Mech. Engineering</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>Secretary to the Director-General of Dy. Director’s status</td>
<td>1</td>
</tr>
</tbody>
</table>

The sanction of the Board is also accorded to the existing posts of the Asstt. Chief Design Engineer (Signal & Telecommunication), Central Standards Office being integrated into the new organization with the upgraded status of a Deputy Director.

5. The pay applicable to Joint Director, Dy. Directors and Assistant Directors, will be regulated as applicable to Chief Design Engineer, Dy. Chief Design Engineers and Asstt. Chief Design Engineers of the existing Central Standards Office respectively, namely:-

5(i) “The pay and special pay of the Joint Director will be regulated on the same basis as that of Joint Directors, Railway Board, except that he may draw the pay of the Senior Administrative grade, without any special pay, if under the next below rule he is entitled to draw pay in that grade”.

This has the sanction of the President and will have effect from 1.5.1959.

(ii) The Dy. Director will draw pay in the Jr. Administrative Grade if he is due promotion to that grade on his parent Railway otherwise he will draw pay only in Sr. Scale and will be eligible to draw a special pay of Rs. 200/- p.m. Officers who are not officiating in the Senior Scale on their parent Railways will not be appointed to this post.

(iii) An officer appointed against the other posts will draw the pay in the scale (viz. Class II, Junior Scale or Senior Scale as the case may be admissible to him on his parent Railway plus a special pay of Rs. 150/- p.m. The Staff of Central Standard Office in RDSO when promoted to these posts will draw pay in Class II plus a special pay of Rs. 150/- p.m.
6. If, under the rules in force, any person appointed to these posts is entitled to pre-1931 scales of pay, his pay thus will be regulated accordingly.

7. This issues with the President’s approval.

Sd/-

(D.C. Baijal)
Secretary, Railway Board

No. ERB7/10/2/RBI
NEW DELHI, 7th March 1957

Copy forwarded to:-

1. All General Managers, Indian Railways including C.L.W.
2. The Chief Administrative Officer, Integral Coach Factory, Perambur.
3. The F.A. & C.A.O., Northern Railway, New Delhi.
4. D.A.O., Northern Railway, New Delhi & Lucknow.

Sd/-

(D.C. Baijal)
Secretary, Railway Board

No. E53/RB7/10/2
NEW DELHI, 7th March 1957

Copy forwarded to the Chief Auditor, Northern Railway.

Sd/-

For Financial Commissioner, Railways
K.C. Sood,

Government of India
Member Engineering
Ministry of Railways,
(Railway Board)
New Delhi

D. O. No. 67JWSC/TK/5
Dated 16.10.1967

Sub : Increase of speed on the Delhi-Howrah section-feasibility study.

My dear Mathur,

I am enclosing a copy of a note recorded, of the discussions held on the afternoon of 7th October, 1967. It has been decided that the feasibility study as indicated in the note should be undertaken by the RDSO as expeditiously as possible. This project should be given the highest possible priority. A team of Senior Officers should be nominated and placed on special duty for this project. It is appreciated that the diversion of capacity to this special project would mean postponement and slowing down of certain other projects now in progress with RDSO.

2. Copies of this letter and the note are being sent to Sahai and Mukherjee, with the request to give all assistance required by the RDSO for conducting the study.

Yours sincerely,

Encl. One

Sd/

(K. C. Sood)

Shri P. N. Mathur,
Director General
RDSO,
Alambagh, Lucknow.

Copy forwarded to :-

1. Shri P. Sahai, General Manager, Northern Railway, Baroda House, New Delhi.
2. Shri K. K. Mukherjee, General Manager, Eastern Railway, Fairlie Place, Calcutta.

It is requested that all assistance required by the RDSO for the feasibility study mentioned above be given and suitable instructions in this respect issued to the departmental officers and to the Divisional Supdts. of your railway. The Engineer-in-Chief (Track), Eastern Railway and the Dy. Chief Engineer(G), Northern Railway should consider this work as their primary assignment for the period the study is in progress.

Sd/-

K. C. Sood
Member Engineering,
Railway Board.
INTRODUCTION OF A SPEED OF 120 KM/H ON THE DELHI-HOWRAH ROUTE

1. The up-to-date position with regard to the introduction of a speed of 120 km/h on the trunk routes was discussed recently in the Board’s meetings. A fact that emerges out of these discussions is that trains at higher speeds could be introduced only if this could be achieved without any large scale additional expenditure on track, signalling and rolling stock. How far this would be possible can be ascertained only if a detailed feasibility study is conducted on selected routes. This matter was, therefore, discussed by me with DG, RDSO, on the afternoon of 7th October, 1967, AMW and DCE from the Board and DSM, Dy. DG and JDRM-II from the RDSO were present at these discussions.

2. It was indicated by me that the feasibility study may be conducted in the first instance on the Delhi-Howrah route. The Delhi-Howrah route was selected for the study in the first instance, since certain amount of data regarding this route has already been collected in connection with the investigations on riding qualities of the WAM1 loco. Further, the difficulties on the Delhi-Howrah route are likely to be somewhat more than on the Delhi-Bombay route and the detailed study undertaken on the Delhi-Howrah route would cover most of the aspects likely to be met with on the Delhi-Bombay route.

3. The aspects required to be considered are

   (i) Signalling
   (ii) Bridges
   (iii) Rolling stock
   (iv) Track

4. As regards signalling, it was considered that the trains which are to operate at a speed of 120 km/h should have sufficient brake power with provision of air brake, if considered necessary, to be able to function with the signalling systems, as at present available on the trunk routes. ATC and other improvements need not be considered as essential features for the operation of a limited number of passenger trains at the speed of 120 km/h.

5. It is considered that the existing types of diesel locos and coaching stock may be permitted to operate at a speed of 120 km/h on bridges over which no speed restrictions exist at present.

6. It is necessary that for the high speed operation we should use the loco with the best riding characteristics from among the diesel locos now available with us. A preliminary study seems to indicate that WDM4 loco should be used for the feasibility study for high speed operation on the Delhi-Howrah section. The study may later be extended to WDM2 loco also. The MAN-HAL and ICF coaches are to be covered by the study.
7. The recent studies undertaken in connection with the WAM1 loco indicate that while the minimum standard of track maintenance required for operating at speeds up to 100 km/h exist on the section from Delhi to Howrah—except for certain short lengths covered by local speed restrictions, the general standard of maintenance varies from section to section of the route. Certain of the sections may be suitable for the operation of WDM4 locos and MAN-HAL/ICF coaches at 120 km/h. On certain sections the track in its present standard of maintenance may not be sufficiently satisfactory for day to day operation of trains at 120 km/h. Modernization, rehabilitation and improvement in track maintenance, standards are expensive and time consuming processes. But in certain of the sections which are at present not suitable for 120 km/h, it may be possible to improve the track maintenance standards by directed maintenance aimed at the rectification of specific defects which come to light by track recording and through local inspection. If such improvements could be effected at a small additional expenditure could be ensured that the improved standards could be maintained round the year, it should be possible to permit the higher speeds over such sections also.

8. As a result of the discussions held on the afternoon of 7th October, it was decided that DG, RDSO, should nominate and place on special duty a team of selected engineers from his organisation for the detailed feasibility study indicated above to be conducted on the Delhi-Howrah route. They would undertake the feasibility studies with the assistance of the Northern and Eastern Railways. The study should be completed by the end of February, 1968. Track recording of the Mughalsarai-Howrah section has been done recently. The track recording of the Delhi-Mughalsarai section should also be done immediately, so that the characteristics of the track as existing during monsoon conditions could be ascertained. Oscillation trials should be conducted with the WDM4 loco and MAN-HAL and ICF coaches. The increase of speeds to be permitted during these trials would depend on the behaviour of the vehicle at lower speeds as indicated on the oscillation charts. It should be ensured that the rolling stock so tested is in good maintenance condition and corresponding to standards which are proposed to be specified for the normal operation of high speed trains. An assessment should be obtained as regards sections as at present existing over which a speed of 120 km/h could be permitted. A comparative study should also be possible with the track characteristics on the various sections as available from the track recording charts. A general assessment should be made as regards the minimum track maintenance standards which would be required for permitting the speed of 120 km/h for the loco and the coaches to their present design. An effort should then be made to improve the track maintenance standards on the sections, where the preliminary study shows that the higher speeds could be permitted with improvements which are feasible with the present track structure and without any large additional expenditure. Additional oscillation trials and track recording would require to be conducted on such improved track also. Further trials may be necessary to ascertain whether the improvements
effected could be sustained over a period of time. An assessment of additional expenditure involved for improving the track should also be made.

9. The procedure as outlined above and discussed with DG, RDSO, is meant only for general guidance of the team, who would be responsible for the feasibility study. The purpose of the study is to ascertain whether the rolling stock to the present designs could be permitted over the major part of the distance between Delhi and Howrah at a speed of

120 km/h without any large additional expenditure on track and rolling stock.

The study should also cover the question of standards to be laid down for track and rolling stock maintenance to be followed for the operation at 120 km/h.

In case the feasibility study indicates that the diesel locos at present available to us and the coaching stock (MAN-HAL/ICF) to the present design could not be operated at speed of 120 km/h over the Delhi-Howrah section, unless large scale expenditure is incurred in track rehabilitation and maintenance, a study should be made as to the improvements, which could be effected to the loco and the coaching stock for permitting the sanction of the rolling stock over the track brought up to the standards which could be achieved without large scale expenditure.

Sd/-

K. C. Sood

M. E.

16.10.67
Annexure-III

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

No. 2005/CE-II/TS/7 Pt New Delhi-110001, dt. 09/05/06

General Managers,
CR, ER, ECR, ECoR, NR, NCR, NER, NFR, SCR, SER, WR, WCR

Sub: Increase in axle load of freight wagons.

1.0 Board has approved running of CC+8+2T loaded BOXN wagons for iron/other ores on identified routes and CC+6+2T loaded BOXN, BOBR and BOBRN wagons for identified routes for carrying coal of ‘E’, ‘F’ and inferior grade.

2.0 Board has further approved running of CC+8+2T and CC+6+2T loaded wagons routes indicated as under.

For CC+8+2T

ER Durgapur-Bardhman
Only ON Slow line which is pre-dominantly loading line
ECoR Koraputt-Rayagada
SER Adra-Midnapur
WCR Manikpur-Jabalpur

For CC+6+2T

CR Roha-Panvel-Diva-Vasai
Khandwa-Bhusawal
ER Khana Link-Kumedpur via Gomai, Malda Town
Asansol-Durgapur, Pradhankhunta-Asansole
ECR GHD-Sonnagar, GHD-RNQ
Phusro-PKA via Kathras-Pathedih, Kathras-Nichitpur, Kusunda-Tetulmari
Dhanbad-Mughalsarai
ECoR VZM-RGDA-KRPU-JDB
SQQ-KIA-BHC
NR Delhi-Ambala, Mughalsarai-Ropar/Suratgarh via Zafarabad UTR-Moradabad, Mughalsarai-Tanda, Mughalsarai-Unchahar, GZB-DLI, Palwal-TRD including third line, Delhi-Area.

NCR Mughalsarai-Ghaziabad, Bina-Palwal
The notification in this regard will be issued by Traffic Commercial Rates, Directorate. The above routes indicate in para 2.0 above are included in Pilot Project.

4.0 The conditions indicated in annexure-I will be applicable for running of such trains in addition following needs to be ensured.

(i) CRS sanction may be obtained in regular manner latest by 31-07-06.
(ii) WILD equipment should be installed within three months of developing vender for supply.

DA-One

(V.K.Jain)
Executive Director Civil Engg. (P),
Railway Board.

Copy- for kind information and necessary action to

(i) DG/RDSO with the request that RDSO should identify the bridges for instrumentation keeping in view the type of bridges already identified by the Zonal railways and direct the zonal railways accordingly to cover more bridges.

(ii) EOCE/B&S/RB
(iii) EDTC(R)/RB

Sub:- Conditionalities for running of increased axle load freight trains (CC+6+2T)BOXN for coal and CC+8+2T for iron ore routes.

1.0 The extent directions in respect of weighment, circulated vide Boards letter No. TCI/2004/109/4 dated 04.11.2004, which was issued while permitting CC+4+2 in general, shall continue to be applicable for this.

2.0 The haulage of 58 BOXN wagons with (CC+6+2) load, would require adequate powering’ and higher tractive/braking forces. It will also have higher trailing loads. It is therefore essential to:-
a) Record the loading spectrum actually passing over the track and bridges during the period. For this purpose, adequate number of Wheel Impact Load Detector should be installed on each Railway. Some Engineer (SE/JE), specifically nominated by PCE/GE, should take the recording. The installation and maintenance should be ensured by Engineering department.

b) Analysing and monitoring of effects.

Therefore, Engineering Deptt. shall keep the Track and Bridges on these routes under observation, with review being done at least every quarter. Specific items for this monitoring are as under:-

2.1 Track

2.1.1 Track structure related speed restrictions - The maximum permitted speed for these loaded freight trains, will be 60 Kmph. In case of 90 R rails, the maximum speed permitted shall not exceed 30 Kmph for loaded and 50 kmph for empty. It will be further subject to other restrictions in force. The railways shall take action to replace 90R rails, if any, on priority.

2.1.2 USFD testing - With increased loading, especially with respect to 90 UTS rails, the phenomenon of rolling contact fatigue (RCF), is likely to take place. The USFD technique to detect RCF, is already available. This may be especially kept in view while doing USFD examination of rails as per existing instructions.

Based on the experience, in the initial period of operations, USFD testing at appropriate frequency, to detect RCF defects, should be under taken in due course.

2.2 Bridges

2.2.1 Each bridge needs to be evaluated as an individual entity regarding safety vis-à-vis its physical condition.

a) Thorough physical inspection as per proforma in Bridge Inspection register, shall be done for each bridge, at the start of pilot project.

b) The bridges found distressed, shall be sanctioned for rehabilitation immediately and taken up.

c) All bridges shall be analysed for the expected loading and where required rehabilitation/strengthening sanctioned and taken up.

d) The speed restrictions as are required from safety considerations, shall be imposed.

2.2.2 Sample bridges (representing type, and span of those available on the routes) and vulnerable bridges, shall be selected for instrumentation, for monitoring the effects of increased longitudinal loads and higher axle loads on the bridge components i.e. foundations, piers and abutments, bearings and super structure.

Instrumentation shall be with respect to measurement of settlement of foundations, tilting of piers/abutments, loads on bearings, deflections and stresses at critical points. Change in dynamic parameters may be monitored for quick evaluation. NDT tests may be carried out periodically.
2.2.3 Bridge Load Monitoring system has been developed & demonstrated by M/s. Sharma Associates, Chicago, USA. Zonal railway should install one of the system to monitor the load, spectrum including dynamic augment coming on the bridges.

2.2.4 Further bridge instrumentation & observations should cover:

2.2.4.1 Longitudinal load coming on bearing & proportion transferred to approaches should be measured.

2.2.4.2 The tilting, if any, of abutment/pier, pressures at critical locations & settlements shall be monitored. This can be done by use of Tiltmeters & flat jacks.

2.2.4.3 Deflection and stresses at critical locations.

2.2.4.4 Dynamic augment coming on bridge to be measured.

2.2.4.5 Dynamic characteristics and changes thereof to monitor health of bridges using vibration signature techniques. Equipment procured by KRCL may be studied.

2.2.4.6 Temperature stress & effect of temperature should be recorded to measure net stress due to loads.

The measurement & parameters may be continuous real time or intermittent quarterly initially for one year and some parameters to be observed over a period of 3 years with reduced frequency.

2.2.5 Frequency of Tests

2.2.5.1 The tests for, longitudinal loads on bearings and proportion transferred to approaches be done initially and further tests as may be required after analysis of results of tests.

2.2.5.2 The test for deflection/tilts & stresses at most critical points be done initially and repeated quarterly for one year and thereafter annually for three years or as otherwise required after study of test results.

2.2.5.3 Tests for Dynamic Characteristics i.e. Vibration Signature test for the bridge be repeated once a quarter for one year & then annually.

2.2.5.4 Load spectrum analysis including dynamic augment shall require continuous record. These system may be got installed with recording over a quarter by agency and thereafter Railway personnel could get trained & take over recording.

2.2.5.5 NDT tests be carried out once in six months for detection of any hidden defects/ cracks development.

2.2.6 Instrumentation and evaluation of bridges needs to specialized agencies. Some of the suggested agencies are:-

(a) SERC, Chennai
(b) CRRI, New Delhi
(c) PIXEL Networks /IIT, Mumbai.
(d) Sharma Associates, Chicago.
(e) Bridge Diagnostic, YSA
Railway may finalise with one or more agencies (depending upon their availability of resources and commitments) at the earliest so that monitoring starts along with the pilot project

2.2.7 Zonal Railway shall fix up with Geotechnical Engg. specialized agencies separately for determining insitu bearing capacity of foundation strata where required in critical bridges. The insitu bearing capacity may be determined using Cone Penetro meters/Pressure meter tests or other such tests as considered, necessary.

2.2.8 The work assigned to the agencies shall include preparation of analytical model, computer analysis and rating of bridges.

2.2.9 The offers shall be finalized within 3 weeks. Inspection shall be started immediately thereafter. The frequency of the tests has been specified at para 3.3 & 3.4 above.

2.3.0 Funds may be charged to Revenue as this is a maintenance activity.

2.3.1 Foreign exchange may be required for a few items. For this, LC may be opened in favour of the firm as per extant procedures.

2.3.2 The fixing of agencies for instrumentation, recording of observations and submission of reports be fixed by the General Managers as works contracts under GM’s powers for inviting and finalizing single/limited tenders treating the works as Urgent Safety Works. Procedures for getting works done through Govt. agencies in case of Govt. research labs may be followed for SERC & CRRI Le as a Deposit Work as per E1116 against estimates submitted by them.

2.3.4 Weekly progress reports be submitted to Railway Board. The first comprehensive technical report may be submitted at the end of first quarter of testing.

3.0 RDSO shall also associate in these studies & and monitoring exercises so as to evaluate the effect of running all these freight stocks in these sections.

4.0 Since we are, going to operate at a very high traffic density level, it is of paramount importance that strict discipline is observed by all concerned and severe punitive measures are taken for any overloading that may come to light. With this in view and for ensuring strict compliance in observance of rules as laid down. Quarterly review shall be done by a multi-disciplinary core group comprising of concerned PHODs namely PCE/CE(Coord.), CME, CEE and COM under .GM of respective Zonal Railways, and a report sent to Board.
List of Officers in RDSO during 1959-60

(Research, Designs and Standards Organisation, Simla)

Sri P.C. Neogi Director General
Sri Lal Das Secretary to Director General
Sri Atma Ram Establishment Officer

Civil Directorate

Sri V. Venkataramayya Director Standards (Civil)
Sri H.H. Banerjee Joint Director Standards (Track)
Sri S.S. Verma Joint Director Standards (Building and Structure)
Sri B.N. Gupta Dy. Director Standards (Building and Structure)
Sri J.S. Bhavra Asst. Director Standards (Civil)
Sri T.C. Tewani Sectional Officer (Metric) Civil
Sri G. Chakrapani Sectional Officer (Building and Structure)-I
Sri M.W. Desai Sectional Officer (Building and Structure)-II
Sri R.V. Naraynan Sectional Officer (Building and Structure)-III
Sri M.R. Ambulkar Sectional Officer (Metric) Civil

Architectural Wing

Sri M.B. Shroff Joint Director Standards (Architecture)
Sri N.V. Shastri Deputy Director Standards (Architecture)
Sri G.R. Bahulkar Assistant Director Standards (Architecture)

Signal and Telecommunication Wing

Sri Laljee Singh Joint Director Standards (Signal and Telecommunications)
Sri S.S. Lal Deputy Director Standards (Signal and Telecommunications)
Sri H.S. Sodhi Asstt. Director Standards (Signal and Telecommunications)
Sri N. Chattopadhyay Sectional Officer (Signal and Telecommunications)-I
Sri R. Srinivasan Sectional Officer (Signal and Telecommunications)-II
Sri K.S. Kale Sectional Officer (Metric) (Signal and Telecommunications)
Sri P.C. Roy Sectional Officer (Telecommunications)
Bridges and Floods Wing

Sri V.P. Riberio Director (Bridges and Floods), New Delhi

Mechanical Directorate

Sri I.C. Bahree Director Standards (Mechanical)
Sri D. Kumar Joint Director (Carriage)
Sri D.V.K. Sastri Joint Director Standards (Electrical)
Sri R.K. Sethi Joint Director Standards (Diesel)
Sri R. Krishnamurti Joint Director Standards (Loco)
Sri R. Rajagopalan Joint Director Standards (Wagon)
Sri P.N. Talwar Dy. Director Standards (Carriage)
Sri J.M. Kapur Dy. Director Standards (Wagon Design)
Sri M.M. Suri Dy. Director Standards (Diesel)
Sri P.V.S. Sastry Senior Inspecting Engineer
Sri S. Krishnaswamy Assistant Director Standards (Diesel)
Sri K.S. Krishnan Assistant Director Standards (Loco)
Sri I.M. Sahni Assistant Director (Specification)
Sri B.L. Bailur Assistant Director Standards (Wagon-I)
Sri C.M. Malik Assistant Director Standards (Wagon-II)
Sri M.C. Pal Sectional Officer (Carriage and Wagon)-I
Sri D.A. Fernandes Sectional Officer (Carriage and Wagon)-II
Sri Anup Singh Sectional Officer (Carriage and Wagon)-III on deputation to West Germany
Sri S.K. Banerjee Sectional Officer (Central Part Drawing Office)
Sri A.S. Nagra Sectional Officer (Electrical)
Sri T.N. Srinivasan Sectional Officer (Loco-I)
Sri S.H. Subbanna Sectional Officer (Loco-II)
Sri Hardas Singh Sectional Officer (Metric-Carriage and Wagon)
Sri D.N.V. Chellam Sectional Officer (Metric) – Loco
Sri R.N. Sinha Liaison Engineer
Sri Prem Prakash Trainee Officer

Research Directorate

Sri K.K. Rao Director Research
Sri R.L. Vohra Joint Director Research (Mechanical)
Sri Y.L. Tandon  Dy. Director (Civil)
Sri G.H. Keswani  Dy. Director (I and P)
Sri A.K. Srivastava  Dy. Director (Mechanical)
Sri C.S.P. Sastry  Dy. Director (Oscillation Trials)
Sri S.N. Ramaswamy  Assistant Director (Building)
Sri K. Bhattacharya  Assistant Director (I and P)
Sri O.P. Kapur  Assistant Director (Soil Mechanics)
Sri B.V. Mallya  Dynamometer Car Officer
Sri M.B. Ramchandani  Oscillograph Car Officer-II
Sri T.A. Ramachandran  Oscillograph Car Officer-III

**Mechanical and Chemical Sub-centre, Chittaranjan**

Sri K.C. Choudhuri  Joint Director Research (Metallurgical and Chemical)
Sri S. Ramanujan  Dy. Director (Metallurgical and Chemical)
Sri D.N. Hazra  Assistant Director ((Metallurgical)
Sri V.R.S. Subramanian  Chemist and Metallurgist-I
Sri M.N. Bhide  Chemist and Metallurgist-II

**Note:** As contained in the Report by the Railway Board for Indian Railways 1959-60 (Vol. I, p 147-148).
Annexure-V

List of Senior Officers up to Dy. Directors Level in RDSO in December 1964

**DG’s Secretariat-Lucknow**

Sri De Sa, R.E. Director General (From 22.10.61 to 1.4.64)
Sri Kapoor, P.C. Director General (From 18.8.64)
Sri Lal Das Secretary to DG
Sri Gupta, P.C. Jt. Director (Finance)
Sri Poonawala, S.H. Dy. Director (Finance)
Sri Tuli, R.L. Establishment Officer
And nine other Asst. officers and Sectional Officers.

**Civil Directorate Designs, Simla**

Sri Rao, K.K. Director Standards (Civil)

**Track Wing**

Sri Varughese, T.M. Jt. Director Standards (Track) at Simla
Sri Sastry, R.M. Dy. Director Standards (Track) at Lucknow
And three other Asst. Directors and Sectional Officers at Simla 2 other officers at Lucknow

**Architectural Wing, Simla**

Sri Shastri, N.V. Jt. Director Standards (Arch.) and 1 Asst. Director

**Bridge and Structures Wing, Simla**

Sri Mukherjee, P.K. Jt. Director Standards (B&S)
Sri Jaini, K.C. Dy. Director Standards (B&S-II)
Sri Venkatakrishna,K.R. Dy. Director Standards (B&S-I)
And six other Asst. Directors and Sectional Officers

**Signal & Telecommunication Wing, Simla**

Sri Jacob, K.J.M Jt. Director Standards (S&T)
Sri Krishnan, M.S. Dy. Director Standards (Sig.)
Sri Kale, K.S. Dy. Director Standards (Tele)
And twelve other Asst. Directors and Sectional Officers

**Mechanical Directorate-Designs, Lucknow**

**Loco Wing**

Sri Krishnamurthi, R Director Standards (Mech.)
Sri Lal, B.B. Jt. Director Standards (Loco)
Sri Krishnan, K.S. Dy. Director Standards (Loco)
And twelve other Asst. Directors, Sectional Officers and Inspecting Engineers for inspection cells at Lucknow and Durgapur.

Carriage and Wagon Directorate, Lucknow

Sri Vohra, R.L. Addl. Director Standards (Mech.) (From 10.5.62)
Sri Puri, M.L. Addl. Director Standards (Mech.) (From 25.6.64)

Carriage Wing
Sri Kochar, D.R. Jt. Director Standards (Carriage)
Sri Kelkar, M.V. Dy. Director Standards (Carriage)
Sri Seth, R.N. Dy. Director Standards (Carriage)
And four other Asst. Directors and Sectional Officers

Wagon Wing
Sri Malik, C.M. Jt. Director Standards (Wagon)
Sri Tandon, T.N. Dy. Director Standards (Wagon)
And twelve other Asst. Directors and Sectional Officers

Inspection Cell, Calcutta
Sri King, E.C. Dy. Director (Liaison-I)
Sri Pal, M.C. Dy. Director (Liaison-II)
And one other Liaison Officer (Wagon Inspection) at Muzaffarpur

Research Directorate, Lucknow
Sri Rao, T.A. Director Research

Civil Branch
Sri Joseph, T.V. Jt. Director, Research (Civil)
Sri Ramaswamy, S.N. Dy. Director (Soil Mechanics)
Sri Murti, V.S. Dy. Director Research (Civil)
And five other Asst. Directors

Mechanical Branch
Sri Kapur, J.M. Jt. Director, Research (Mech.)
Sri Srivastava, A.K. Dy. Director, Research (OT)
Sri Mallya, B.V. Dy. Director, Research (Mech.)
Sri Luthra, S.P. Dy. Director, Research (Mech.)
Sri Chandra Mohan Dy. Director, Research (Mech.)
And nine other Asst. Directors, Oscillograph and Dynamometer car officers and Sectional Officers
Safety Branch
Sri Agerwala, M.M. Jt. Director, Research (Safety) along with one Asst. Director

Publication Branch and Ministerial Branch (Research)
Sri Moorjani, G.C. Dy. Director (Publication) along with 1 Asst. Director and 1 Sectional Officer

Bridges and Floods Directorate
Sri Bhatnagar, AS. Dy. Director (B&F)

Mechanical Designs Directorate
Diesel Branch
Sri Pant, T.C. Jt. Director (Diesel)
Sri Bhalla, P Dy. Director (Diesel)
Sri Anup Singh Dy. Director (Diesel)
Sri Krishnaswamy.S Dy. Director (Diesel)
And nine other Asst. Directors.

Electrical Designs Directorate
Sri Vajramushti, V.R. Director Standards Electrical
Sri Kanjilal, S.K. Jt. Director (Electrical)
Sri Fondekar, V.K. Dy. Director Electrical
And two other Asst. Directors and 1 Sectional Officer.

Chittaranjan Research Directorate
Metallurgical and Chemical Branch - Chittaranjan
Sri Choudhuri, K.C. Jt. Director (M&C)
Sri Pandit, N.V. Dy. Director (Met.)
Sri Bhaduri, A.S.(Dr.) Dy. Director (Met.)
And eight other Asst. Directors, Chemist and Metallurgist and Sectional Officers.

Note: The information is based on Classified List of Indian Railways p. 21-30, December 1964).
### OFFICERS AND STAFF STRENGTH IN RDSO DURING DIFFERENT TIMES

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<thead>
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*This strength is for RTRC including M&C at CLW, Chittaranjan.

**Note:** The above statement is based on figures given in various Annual Reports of RDSO.
Note on Schedule of Dimensions received from Track Directorate of RDSO in February, 2007

Though the railway came to India in 1853, evidence suggests that the first Schedule of Dimensions was adopted in 1913 on Broad Gauge (BG). In year 1922, Railway Board issued a Schedule of maximum, minimum and recommended dimensions to be observed on BG in India modifying certain dimensions of 1913 schedule to permit use of larger rolling stock.

In 1926, recommended dimensions of 1922 schedule were ordered for implementation in all new works and alterations to existing works but shortly after a relaxation in the case of certain recommended dimensions, the adoption of which would involve heavy expenditure in remodelling works was allowed.

In 1929, it was found desirable further to amend the Schedule of 1922 in order to introduce certain improvements in the light of experience gained, and to provide the clearances required by electric traction equipment on lines which were likely to be electrified in the future. The dimensions which were more of the nature of current practice than essential for safe working were relegated to Schedule II, Recommended Dimensions.

In 1936, however, the financial stringency on Railways brought to the front the urgent necessity for restricting capital expenditure to a minimum. In these circumstances it was found desirable to alter the dimensions prescribed in Schedule I of the 1929 Dimensions and to revert to the maximum and minimum dimensions in the 1922 Schedule in several important respects. These alterations were not, however, intended to prevent the introduction of 3660mm stock at some future date should this prove necessary and therefore it was laid down that the modifications were not to apply to Tunnels, Through and Semi-through Girder Bridges in respect of which the Standard Dimensions of 1929 would continue to apply.

The SOD was printed in the year 1939, 1958 and 1973. The Schedule of dimensions printed in 1973 was with metric and F.P.S dimensions. Schedule II & III, showing Recommended Dimensions and Infringements of Schedule I respectively, which might be permitted on existing railways, were retained and the appendix dealing with extra clearances required on curves were revised to show the clearances required for 3250mm wide and 21340mm long rolling stock. The dimensions prescribed in Schedule I which were essential for safe working, were applicable to all new railways and to new works on existing railways, including, so far as practicable, alternations and renewals, and sanction was required to a departure from them.

The schedule of dimensions of 1973 version was based on the requirements of 25KV.A.C. traction and all future construction were to be carried out to these dimensions
except in cases where it was considered that there was no chance of the line being subsequently converted to 25KV A.C. traction.

RDSO took several initiatives in order to cater to specified needs of the traffic from time to time. In 1974, a special MMD profile 72227 for double deck coaches was introduced. Similarly in 1981, EDO-T-1043 profile was adopted for wagons, enhancing dimensions over earlier profile.

During year 2000, a major initiative was launched by RDSO for revision of SOD (1973 reprint) and Director General/RDSO appointed a multi disciplinary committee for the revision of Schedule of Dimensions. Based on several discussions in the committee and Board’s approval on the recommendations of the committee, SOD (Revised -2004) was printed in year 2005. This SOD consisted of only metric units and has only two schedules. Schedule-I consists of those items which are mandatory and have to be observed on all 1676mm Gauge Railways in India. Schedule-II consists of items included in Schedule -III of 1973 version of Schedule of Dimensions.

This SOD incorporated MMD which is based on the two profiles viz EDO/T-1043 (for goods stock and locomotive) and EDO/T-72227 (for double deck coach). The width, side height and center height of MMD were increased to 3250mm, 3735mm and 4265mm respectively.

Further initiatives to enhance MMD for increasing throughput and meet demands of fast growing economy of the nation were continued by RDSO. Operation of Double Stack Container (DSC) was cleared in year 2006 on Jaipur- Pipavav section based on studies and trials conducted by RDSO. The operation of Garib Rath coaches with increased center height of 4381mm was cleared by RDSO during year 2007 based on kinematic studies and trials. RDSO is presently working on clearance of new design of covered wagon with center height of 4385 mm, significantly enhancing throughput for carriage of food grain and fertilizers.
PANORAMA
Sri P.P. Kumaramangalam, Chief of the Army Staff (extreme left) at the S&T Lab on 10.1.69

His Excellency Sheikh Faisal M. Al Shehail, President of Saudi Government Rail Road Organisation, Saudi Arabia was welcomed by RDSO on 10.11.80

Chairman of British Railways visited RDSO on 16.6.84

Members of the French Railway delegation during their visit to RDSO on 22.2.87
Sri Madhava Rao Scindia, Minister incharge of Railways with Technology Development Groups of RDSO for synergy with academic institutions and industry meeting at Railway Board on 7.7.88

A view of the meeting during the ESCAP visit to RDSO on 6.11.89

Visit of Sri C.K.Jaffer Sharief, Minister for Railways (1993-94)
Sri Ram Vilas Paswan, Minister for Railways visited RDSO on 9.10.97

Visit of Sri Nitish Kumar, Minister for Railways to RDSO on 22.9.01

Sri R.Velu, Minister of States for Railways in Signal Lab, RDSO on 3.11.04

Pakistan delegation headed by Mr Ishaq Khan Khakwani, MOSR, Pakistan in RDSO on 19.4.05

Japanese delegation from Japan International Cooperation Agency headed by Mr Masuzawa at RDSO on 27.7.06
राजभाषा

अनुसंधान अभिकल्प एवं मानक संगठन (अ.अ. मा.स.) में मुख्य राजभाषा अधिकारी के नियंत्रण में एक राजभाषा अनुभाग है जिसमें राजभाषा अधिकारी तथा हिन्दी सहायक कार्य करते हैं। यह अनुभाग भारत सरकार की राजभाषा नीति के अंतुसार राजभाषा विभाग (गृह मंत्रालय) तथा रेलवे बोर्ड के निर्देशों के अनुसार हिन्दी के प्रयोग को सुनिश्चित करता है। इन कार्यों की समीक्षा के लिए महानिदेशक महोदय की अध्यक्षता में तिमाही बैठकें आयोजित की जाती हैं।

संसदीय राजभाषा समिति द्वारा दिनांक 26-07-1990 को अ.अ. मा.स. में राजभाषा का निरीक्षण किया गया। संसदीय राजभाषा समिति को दिये गये सभी आश्वासन पूरे किये गये, केवल हिन्दी के मूल पत्राचार को शत-प्रतिशत के लक्ष्य तक लाना है, जो इस समय 91 प्रतिशत है।

अ.अ. मा.स. के राजभाषा विभाग द्वारा तैयारित राजभाषा पत्रिका ‘मानक-रशिम’ वर्ष 1997 से प्रकाशित की जा रही है जिसमें तकनीकी तथा गैर-तकनीकी लेखों, कहानियों, यात्रा वृत्तांत और कविताओं को शामिल किया जाता है तथा इसका वितरण सभी भारतीय रेलों, रेलवे बोर्ड, सभी मंडलों तथा उत्पादन उपयोग को किया जाता है।

RWSO Women’s Welfare Organisation (RWWO)

RWWO is a voluntary organisation run by the women for the welfare of the Railway employees and their families and it runs several institutions for welfare of employees and their families. On the Independence Day in 2006, a school building was provided for ‘Arunodya Vidyalaya’ which provides education to mentally and physically handicapped children. In the school, the children are provided speech therapy, yogic exercises, dance and music etc. for their development. This year ‘Arunodya Vidyalaya’ started studies for Class III and further classes will be extended each year.

On 2nd October 2006, ‘Radiant Roses Preprimary School’ was started to provide education to tiny-tots and to prepare them for entry to good schools.

The other main activities of RWWO are:-

- Providing career counselling to students of Class X and XII studying in Manak Nagar Inter College;
- Providing scholarship of Rs. 10,000 per year to brilliant students of Group C & D employees studying in technical/ industrial training institutes;
- Arranging computer training during summer vacations;
- Providing assistance to various institutes running in RDSO such as gifting two televisions and two fridges to RDSO hospital and also gifting television to RPF barrack and Recreation Club;
- On Teacher’s Day it organized games and give away prizes;
- On the occasion of Diwali it distribute sarees and other clothes to its employees.

RWWO has also been running ‘Shilpa Kala Kendra’ in which chiken, crotia and stitching training is provided. In 2006-07, this training is being provided to 47 girls. Under ‘Adult Education Centre’, RWWO is running a library and 51 women are getting education.
RWWO organizes a number of cultural functions including Basant Mela, Mahila Diwas, etc. These functions are colourful and bring cheers to the employees and their families.

The RWWO has been doing an excellent service for the welfare of the RDSO employees and their families and brings cheers to all.

Sri A.K. Rao, Director General inaugurating the ‘Radiant Roses Pre-primary School’ on 02.10.06 under the chairmanship of Smt. Shachi Rao, President, RWWO

Children participating in on the spot painting competition

A scene of Basant Mela held at RDSO Stadium on 3rd & 4th February 2007
Recreation, Games, Sports, Medical and Educational Facilities

Recreation, Games and Sports Facilities: RDSO campus has full facilities for recreation, games and sports for the employees and their families. The main recreational facilities are as under:-

- **Stadium:** RDSO has a spacious and well-laid multi-purpose stadium, which is one of the best in the city (Size 295 m × 196 m). It has two football fields, one hockey field, three basketball courts with floodlights, two cricket pitches and facilities for track and field events. It is situated in the middle of the colony with well laid roads all around which automatically generates sporting atmosphere among the residents.

- **Swimming Pool:** It is a standard swimming pool (25 m × 12.5 m) with modern facilities for filtering, drain, dressing etc. The swimming pool was commissioned in the year 1997.

- **Badminton Courts:** RDSO has a well-equipped indoor badminton hall with two badminton courts of wooden flooring and floodlighting. The badminton hall is among the best in Lucknow. Besides this, RDSO Recreation Club is also having one badminton court.

- **Synthetic Tennis Courts:** RDSO has two synthetic courts properly fenced with floodlighting arrangements. Tennis has become very popular among wards of RDSO employees due to regular coaching facilities.

- **Table Tennis-cum-Badminton Hall:** One table tennis hall with latest TT tables is available. It is a multipurpose hall and can be used for playing badminton also. It has been renovated with wooden flooring. RDSO Recreation Club also has facilities for table tennis with tables of international standard.

- **Gymnasium:** RDSO has two well-equipped gymnasiums one for the officers in the Officers Club and the other for staff in the Subordinate Recreation Club. Earlier it was a combined Gymnasium, which was divided due to over crowding. The Sports Association is adding new equipment to the gymnasium from time to time.

- **Recreational Centres, RDSO Club for officers and staff etc.:** RDSO has separate clubs for officers and staff. Officer’s Club has a well equipped gymnasium and a billiards room. Subordinate Recreation Club also has many facilities for sports and games like gymnasium, table tennis, carom, chess, badminton, cards, etc.

  Employees and their wards regularly make use of these facilities and frequently tournaments, sports competitions etc. are organized.

**National level participants and achievers**

Following players have participated in national level games:-

- **Basketball:** Sri Suparsh Awasthi represented Indian Railways in the Senior Nationals in 1978, 1979, 1980 and 1983 and he also represented U.P. State in the Senior Nationals for 15 years. Sri Upendra Kumar and Sri Sunil Kumar Pal also represented Indian Railways as well as U.P. State in the Senior Nationals.
- **Hockey**: Sri Kanti Das, Sri Ratan Chowdhary, Mohd. Ilyas had represented Indian Railways as well as U.P.State in the Senior Nationals during the period from 1978-1982.
- **Cricket**: S/Sri S.N.Puri, Arun Bajaj, Chetan Sachdeva and Sandeep Mehrotra represented the state in the Ranji Trophy.
- **Football**: Sri Mehandi Abbas represented U.P.State in Santosh Trophy for 16 years during 1969-1990 and was also captain of the state team in 1976. Sri S.P.Chatterjee represented U.P.State in Santosh Trophy for 10 years. S/Sri Trilok Nath, Jagmohan and Karan Singh also represented U.P.State in Santosh Trophy for several years.
- **Athletics**: Sri Mohan Lal won the first medal for RDSO at Inter Railway level i.e. third place in Steeple Chase in 1981. He participated in several marathon races. He won second place in Inter Railway Championship in marathon in 1985 and third place in 1986. He secured sixth place in the Pune International Marathon in 1985 and fourth place in Open India Indira Marathon in 1985, 1986 & 1987.
- **National level coach in basketball**: Bhupendra Shahi is an excellent basketball player and has been Indian Railway Women Basketball team coach for 12 years during 1993-1997 and 2000-2006 and the Indian Railways team won Gold Medal on 11 occasions and Silver Medal on one occasion at the Senior Nationals. He has also been Indian Women team coach in Asian Basketball Championship, Bangkok in 2004. He was awarded at the Railway Ministers level for his excellent performance.
- **Sri Suparsh Awasthi** has been Indian Railway Men Basketball team coach in 1992 and got Gold Medal in Senior Basketball Championship.


For meeting the cultural needs of the employees and their families, RDSO has a modern centrally air-conditioned auditorium with 354 seating capacity where cultural functions including drama and cultural evenings are organized. Rajdhani Hall which was gifted by the Railway Board on introduction of the first Rajdhani in 1969, is used for organizing private functions by the Railway employees. Most of the marriages in RDSO are organized in the Rajdhani Hall. In addition to Rajdhani Hall, there is a Baraat Ghar for organizing private functions. There is a shopping complex with 21 shops meeting daily requirements of the residents.

**Medical facilities**

There is a 30-bedded hospital in RDSO with nine doctors. It is equipped with ultrasonography, 500 mm x-ray machine, auto analyzer, cell counter, electrolyte analyzer, cardiac monitor, neonatal incubator, defibrillator and a full-fledged physiotherapy unit with all modern gadgets. Honorary visiting consultants of all specialty and super specialty are enrolled in this hospital. They are giving their services to patients whenever required.
Educational facilities

There are excellent educational facilities for the wards of the employees in the campus. The main educational institutions are as under:-

- Kendriya Vidyalaya up to Class XII. It is a project school of RDSO and the building was constructed by RDSO.
- City Montessori School;
- St. Mary’s Convent School up to Class XII with ICSE Board;
- Manak Nagar Railway Inter College; and
- Bal Vidyalaya run by RWWO.
Recipients of Railway Ministers Awards For R&D

2006

Group Cash Award of Rupees five lacs for excellent work done in enhancing the carrying capacity of BOXN wagons to CC+8+2 t on identified iron ore routes to officers and staff of Track and B&S Directorates;

- Group cash award of Rupees Five lacs for improved productivity of freight stock by increase in pay load during 2005-06 to the Mechanical Departments (Directorates) of RDSO;
- Group cash award of Rupees three lacs to Sr ED (MP) and his team of officers and staff in appreciation of the good work done by them in helping to increase the movement of freight traffic;

2005

Sri B.K. Saxena, Assistant Research Officer (M&C) was awarded for developing ‘Ultrasonic Rail Tester’ for detection of gauge face corner defects and for developing ‘Ultrasonic AT Weld Tester’ for detection of defects in AT welds which have greatly enhanced flaw detection capability and thereby improved track safety. He has also brought out several quality improvement measures for enhancing safety.

2004

Sri Amar Nath Gupta, Dy. Director (Track) was awarded for developing an innovative design of sleeper having anti-vandal character to prevent sabotage in fish-plated track. With this design of sleeper, the removal of rail by four persons may take about an hour as against 4 to 5 minutes with normal sleeper. The rail cannot be removed easily even after opening of fishplate bolts and removal of fastenings between rail and sleeper. This has made sabotage difficult by removing fish plates in a fish-plated track.

2003

Sri Ram Kumar, Jr. Engineer (Motive Power) was awarded for improving the suspension system of 140 t BG crane imported from Gottwald GmBH, Germany and thereby increasing its speed from 80 km/h to 100 km/h. The task was challenging and has been done by innovations in which he introduced hydraulic dampers of 1100 kg at 10 cm/sec capacity in the suspension of the Gottwald crane with weld type match truck. The crane has been found suitable with these modifications during oscillations trials at speed of 110 km/h maintained to main line standards.

2002

Sri Anoop Kumar, Director (ED) studied and analyzed various systems and processes of 16 cylinder DLW diesel engine which is the main prime mover in IR. He took systematic configuration build-up of these DLW engines incorporating latest technologies along with extensive testing. In October 2001, he upgraded the DLW
diesel engine to 3300 hp which has already been taken-up for production. In January 2002, he further upgraded the diesel engine to 3600 hp rating.

Sri Vinay Kumar Singh, Section Engineer (TI) was awarded for his insight, hard work and innovative efforts due to which concept of standardisation of the SCADA system for IR took shape and was commissioned on Lucknow-Kanpur section. This is helping IR to bring in economy and improved reliability.

2001

Sri Vineet Kumar Saxena, Director (MP) took initiative to reduce the chances of accidents in the wake of serious accident at Khanna, Northern Railway. Due to his bold move which required a major modification to be introduced on the loco brake and control systems of both diesel and electric to ensure:-

- In case of train parting/ alarm chain pulling on goods/ passenger trains, the train will come to a stop automatically.
- The flasher light will also be switched ‘ON’ automatically along with audio visual indication to the driver.
- In case any miscreants close the angle cock of wagons/ coaches on run, indication of the same will be available to the driver.
- The system will ensure that driver can start the train only after build up of adequate brake pressure avoiding cases of wheel skidding of the train.

The modification has been achieved by totally in-house efforts and is a unique system in the world which will have long lasting impact on improved safety.

2000

Sri Balbir Singh Tahim, Director (Signal) with his team developed an Integrated Power Supply (IPS) system to signalling installation for way side stations to reduce the number of sub-systems and to provide reliable power supply to signalling installation. This will result in enhanced safety due to driver not having to face blank signal due to failure of commercial power supply. It will require reduction in manpower and also energy saving of about Rs. 60,000 per station per annum.

1999

Sri Vipul Kumar, Jt. Director (Track) was doing regular work connected with design, development and inspection of glued rail joints and different elastic fastening components, viz elastic rail clip, GFN liners, GR sole plates. He studied the problem of loss of toe load of elastic rail clip Mark III in the field and with a novel idea designed and developed elastic rail clip Mark V which will provide higher toe load in the field (1200 to 1500 kg) and also has much elastic margin beyond the designed toe load deflection of 13.6 mm. This will result in sustained level of toe load for much longer period and will improve maintainability of concrete sleeper track.

1996

Sri A.K. Mandal, Jt. Director (M&C) has devoted himself to successful introduction of multi-channel ultrasonic rail tester and memory based ultrasonic flaw detector for testing rails and rolling stock axles respectively. This has led to efficient flaw
detection and significant improvement in testing productivity and accuracy thus leading to enhanced safety and reliability. He has developed over 60 codes of procedure for testing of critical components and trained over 400 officers and supervisors apart from quality audit of major workshops to improve safety.

1995

Sri K.K. Dubey, Dy. Director (M&C) has displayed excellent leadership qualities and has put up lot of hard work in development of manufacturing technique for high performance medium phosphorus brake blocks. He personally guided the trial production in Railway foundries which resulted in development of an indigenous process of manufacturing the above brake blocks. The life of these brake blocks is at least 30% more than the life of the conventional brake blocks and is expected to bring about a saving of Rs. 45 crores per annum.

1993

Sri S. N. Agrawal, Jt. Director (TM) as a team leader did an exemplary work. The Track Recording Cars were run as special trains because they could record track geometry only in a narrow speed band of 65 to 85 km/h. This required separate crew and loco besides using up a path of a train. Sri Agrawal’s team upgraded the TRC by using microprocessor technology and speed tunable filters due to which TRC can now record at speeds between 25 km/h to 100 km/h. With this modification, the TRCs can be attached to commercial trains the work has been totally completed indigenously at a cost of Rs. 35 lacs per TRC and will result in an annual saving of about Rs. 60 lacs in running costs per TRC.

1992

Ram Mohan Rao Kallakuru, CTI (Telecom) - The project works of determining the interference effect of thyristor controlled and chopper controlled rolling stock on S&T systems through undertaking of measurements, testing, analysis of the test data and final evaluation of results is delicate and important. A slight in-difference or in-attentiveness can be hazardous for the safety of train operation. These delicate investigation works need thorough knowledge both of the systems as well as the testing and measuring instruments, preciseness and complete involvement with the task. Sri Rao has been associated with such investigation projects. It was because of the pain taking efforts and involvement of the team entrusted with the investigation work, of which, Sri Rao was a key element at the supervisory level that investigation and analysis of the field trials of WAG6C Hitachi 6000 thyristor loco, WAG1 ECIL’s thyristor loco and WAM2 & WAM4 BHEL thyristor locos could be successfully completed pinpointing the excessive level of harmonics and a probable cause. Required modifications in the control circuit were made to contain the harmonics and to bring the performance within the satisfactory level. He has been associated with other investigations also and has made significant contribution in them also.

Sri R.B.L. Sharma, CRA (Instrumentation) and Sri P.C. Chandiramani, CDA (MP): A design of wheel flange lubricator with
indigenous know-how and resources was successfully developed by them within nine months of efforts and experimentation to reduce specific fuel consumption. A prototype has been developed which had been performing satisfactorily at NKJ shed. The design is suitable for both diesel and electric locos.

1991

Sri M.P. Joshi, Design Assistant (Track) – He worked hard and displayed initiative in development of concrete sleepers for turnouts with ‘Fan-shaped’ layouts. He had helped in preparation of computer programmes for computation and preparation of detailed drawings of concrete turnout sleepers. With this design, the same set of concrete sleepers can be used for both left hand and right hand turnouts. This will also eliminate multiplicity of designs and thus leading to cost reduction and inventory control. His contribution in preparing accurate and quality drawings of concrete sleepers for turnouts is commendable.

Sri Ashwani Kumar, Chief Signal Inspector has done extensive work in the field of circuit development of axle counter block as import substitution. Apart from this he has been keenly involved in a number of projects and has substantial personal contribution in the development of:-

- Reduction of line battery voltage for tokenless block instruments;
- Development of circuit for automatic on-line arrangement for double line block instrument;
- Standardisation of circuit diagram for panel interlocking;
- Improvement in software of CAD system for circuit design;
- Design of double line block instrument using interlocked relays;

Sri Ashwani Kumar has contributed considerably towards economizing both expenditure and manpower along with import substitution.

1989

S/Sri S.K. Sinha, Jt. Director (MP), M.V. Balasubramnian, ADE (MP), Harbhajan Singh, CDA (MP), K.K. Maniar, Dy. Director (Carriage) and C.K. Sharma, ARE (Mechanical) were awarded by the MoSR for their significant contribution in the design, development and manufacture of Shatabdi Express.

Note:- Awards have been received by number of other officers and staff for their R&D contributions in earlier years at Railway Ministers level but the details are not readily available and are therefore not given.
Director Generals

Sri P.C. Neogi, IRSE (27.4.59 to 6.11.60)
Sri Qurban Singh, IRSS (8.12.60 to 24.2.61)
Sri A.C. Mukherji, IRSE (25.2.61 to 21.10.61)
Sri RE De Sa, IRSE (22.10.61 to 31.3.64)

Sri P.C. Kapoor, IRSME (18.8.64 to 3.2.65)
Sri K.C. Sood, IRSE (16.3.65 to 13.2.66)
Sri P.N. Mathur, IRSME (20.3.67 to 23.4.68)
Dr. M. Srinivasan, IRSE (23.9.68 to 23.3.74)

Sri T.V. Joseph, IRSE (19.5.74 to 26.2.76)
Sri R.M. Sambamoorthi, IRSE (27.2.76 to 28.6.76)
Sri G.N. Bhattacharya, IRSE (28.6.76 to 31.12.77)
Sri B. Mohanty, IRSE (31.7.78 to 31.12.78)

Sri K.A. Jacob, IRSE (1.1.79 to 18.5.79)
Sri L.F.X. Freitas, IRSE (1.11.80 to 30.11.81)
Sri M.K. Kapur, IRSME (21.12.81 to 11.1.82)
Sri K.G. Belliappa, IRSME (21.1.82 to 23.11.82 & 24.12.82 to 31.12.83)
Director Generals

Sri M.K. Gamkhar, IRSME (25.11.82 to 23.12.82 & 1.1.84 to 31.7.84)

Sri M.K. Modwel, IRSME (19.9.84 to 30.4.85)

Sri T.S. Vardya, IRSSE (16.5.85 to 30.6.86)

Sri V.C.V. Chenulu, IRSEE (2.7.86 to 24.12.87)

Sri D.N. Singh, IRSE (11.3.88 to 30.6.90)

Sri O.P. Jain, IRSSE (30.6.90 to 31.7.92)

Sri H.P. Mittal, IRSME (17.8.92 to 31.1.95)

Sri P.C. Verma, IRSME (1.8.95 to 30.9.97)

Sri Hari Mohan, IRSME (23.10.97 to 28.2.02)

Sri G.K. Wadhwa, IRSME (5.4.02 to 30.6.04)

Sri A.K. Rao, IRSME (since 13.12.04 continuing)
<table>
<thead>
<tr>
<th>Abbreviations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAR</td>
<td>Association of American Railroads</td>
</tr>
<tr>
<td>ABB</td>
<td>Asea Brown Bovri</td>
</tr>
<tr>
<td>ABU</td>
<td>Automatic Braking Unit</td>
</tr>
<tr>
<td>AC</td>
<td>Air-conditioner</td>
</tr>
<tr>
<td>ACD</td>
<td>Anti Collision Device</td>
</tr>
<tr>
<td>AET</td>
<td>Acoustic Emission Technique</td>
</tr>
<tr>
<td>AFTC</td>
<td>Audio Frequency Track Circuit</td>
</tr>
<tr>
<td>ALCO</td>
<td>A American Locomotive Company</td>
</tr>
<tr>
<td>AOH</td>
<td>Annual Overhauling</td>
</tr>
<tr>
<td>AT welding</td>
<td>Alumino Thermit welding</td>
</tr>
<tr>
<td>ATD</td>
<td>Automatic Tensioning Device</td>
</tr>
<tr>
<td>BG</td>
<td>Broad Gauge</td>
</tr>
<tr>
<td>BHEL</td>
<td>Bharat Heavy Electricals Ltd.</td>
</tr>
<tr>
<td>BIS</td>
<td>Bureau of Indian Standards</td>
</tr>
<tr>
<td>BLDC fans</td>
<td>Brushless DC fans</td>
</tr>
<tr>
<td>BNSL</td>
<td>Bhilawan Nut Shell Liquid products</td>
</tr>
<tr>
<td>BOX</td>
<td>Vacuum brake eight wheeler wagon</td>
</tr>
<tr>
<td>BOXN</td>
<td>Air brake eight wheeler</td>
</tr>
<tr>
<td>BRS</td>
<td>British Research Station</td>
</tr>
<tr>
<td>BSC</td>
<td>Bridge Standards Committee</td>
</tr>
<tr>
<td>bsfc</td>
<td>Specific fuel consumption</td>
</tr>
<tr>
<td>BTDC</td>
<td>Before Top Dead Centre</td>
</tr>
<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
</tr>
<tr>
<td>CAMTECH</td>
<td>Centre for Advanced Maintenance Technology, Gwalior</td>
</tr>
<tr>
<td>CASNUB</td>
<td>IR standard cast steel bogie</td>
</tr>
<tr>
<td>CBC</td>
<td>Centre Buffer Coupler</td>
</tr>
<tr>
<td>CBRR</td>
<td>Central Board of Railway Research</td>
</tr>
<tr>
<td>CCF</td>
<td>Coaching Container Flats</td>
</tr>
<tr>
<td>CCRS</td>
<td>Chief Commissioner for Railway Safety</td>
</tr>
<tr>
<td>CFC</td>
<td>Carbon Floro Carbon</td>
</tr>
<tr>
<td>CLS</td>
<td>Colour Light Signal</td>
</tr>
<tr>
<td>CLW</td>
<td>Chittaranjan Locomotive Works</td>
</tr>
<tr>
<td>CMS</td>
<td>Cast Manganese Steel</td>
</tr>
<tr>
<td>CNSL Resin</td>
<td>Cheronut Shell Liquid</td>
</tr>
<tr>
<td>CONCOR</td>
<td>Container Corporation of India Ltd.</td>
</tr>
<tr>
<td>CORE</td>
<td>Central Organisation for Railway Electrification</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>CR</td>
<td>Central Railway</td>
</tr>
<tr>
<td>CRS</td>
<td>Commissioner for Railway Safety</td>
</tr>
<tr>
<td>CSIO</td>
<td>Central Scientific Instrumentation Organisation</td>
</tr>
<tr>
<td>CSIR</td>
<td>Council of Scientific and Industrial Research</td>
</tr>
<tr>
<td>CSO</td>
<td>Central Standards Office</td>
</tr>
<tr>
<td>CSP</td>
<td>Chloro Sulphonated Polythene</td>
</tr>
<tr>
<td>CWC</td>
<td>Central Water Commission</td>
</tr>
<tr>
<td>CWR</td>
<td>Continuous Welded Rail</td>
</tr>
<tr>
<td>DAV</td>
<td>Direct Admission Valves</td>
</tr>
<tr>
<td>DBR</td>
<td>Dynamic Braking Resistance</td>
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<tr>
<td>DFC</td>
<td>Dedicated Freight Corridor</td>
</tr>
<tr>
<td>DLW</td>
<td>Diesel Locomotive Workshop, Varanasi</td>
</tr>
<tr>
<td>DMRC</td>
<td>Delhi Metro Rail Corporation Ltd.</td>
</tr>
<tr>
<td>DMU</td>
<td>Diesel Multiple Unit</td>
</tr>
<tr>
<td>DOE</td>
<td>Department of Electronics</td>
</tr>
<tr>
<td>DRDO</td>
<td>Defence Research &amp; Development Organization</td>
</tr>
<tr>
<td>DTM</td>
<td>Directed Track Maintenance</td>
</tr>
<tr>
<td>DTMF</td>
<td>Dual Tone Multi Frequency</td>
</tr>
<tr>
<td>ECoR</td>
<td>East Coast Railway</td>
</tr>
<tr>
<td>ECR</td>
<td>East Central Railway</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>--------------</td>
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<tr>
<td>EEG</td>
<td>Electro Encphalographic</td>
</tr>
<tr>
<td>EMF</td>
<td>Electro-Magnetic Force</td>
</tr>
<tr>
<td>EMU</td>
<td>Electric Multiple Unit</td>
</tr>
<tr>
<td>EP Contactor</td>
<td>Electro Pneumatic Contactor</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency of USA</td>
</tr>
<tr>
<td>EPDM</td>
<td>Ethylene Propylene Die Monomer</td>
</tr>
<tr>
<td>EPR</td>
<td>Ethylene Propylene Rubber</td>
</tr>
<tr>
<td>ER</td>
<td>Eastern Railway</td>
</tr>
<tr>
<td>ERC</td>
<td>Elastic Rail Clip</td>
</tr>
<tr>
<td>ESMON</td>
<td>Energy-cum-Speed Monitoring System</td>
</tr>
<tr>
<td>EVA</td>
<td>Ethylene Venyl Acetate</td>
</tr>
<tr>
<td>FB</td>
<td>Flash Butt</td>
</tr>
<tr>
<td>FEM</td>
<td>Finite Element Method</td>
</tr>
<tr>
<td>FEPPC</td>
<td>Flood Estimation, Planning and Coordination Committee</td>
</tr>
<tr>
<td>FIP Plunger</td>
<td>Fuel Injection Pump</td>
</tr>
<tr>
<td>FMVFT</td>
<td>Frequency Modulated Voice Frequency Telegraphy</td>
</tr>
<tr>
<td>FRP</td>
<td>Fibre Reinforced Polymer</td>
</tr>
<tr>
<td>FTMB</td>
<td>Front Traction Motor Blower</td>
</tr>
<tr>
<td>GCM</td>
<td>Governing Council meeting</td>
</tr>
<tr>
<td>GFN liner</td>
<td>Glass filled Nylon Liner</td>
</tr>
<tr>
<td>GM locomotive</td>
<td>General Motors Locomotive</td>
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<tr>
<td>GMT</td>
<td>Gross Million Tonnes</td>
</tr>
<tr>
<td>GP</td>
<td>Gas Pressure</td>
</tr>
<tr>
<td>GPR</td>
<td>Ground Penetration Radar</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>GRSP</td>
<td>Grooved Rubber Sole Plate</td>
</tr>
<tr>
<td>GSM-R technology</td>
<td>Global System for Mobile Communication for Railways</td>
</tr>
<tr>
<td>GSR</td>
<td>Galvanic Skin Resistance</td>
</tr>
<tr>
<td>GTKM</td>
<td>Gross tonne kilometers</td>
</tr>
<tr>
<td>GTO</td>
<td>Gate Turn Off</td>
</tr>
<tr>
<td>HAZ</td>
<td>Heat Affected Zone</td>
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<tr>
<td>HCFC</td>
<td>Hydro Chloro Floro Carbon</td>
</tr>
<tr>
<td>HFC</td>
<td>Hydro Floro Carbon</td>
</tr>
<tr>
<td>HM Loading</td>
<td>Heavy Mineral Loading</td>
</tr>
<tr>
<td>HOG</td>
<td>Head on Generation</td>
</tr>
<tr>
<td>HQ equipment</td>
<td>Head Quarter equipment</td>
</tr>
<tr>
<td>HTSC</td>
<td>High Tensile Steel Casting</td>
</tr>
<tr>
<td>ICF</td>
<td>Integral Coach Factory, Chennai</td>
</tr>
<tr>
<td>IDA</td>
<td>International Development Agency</td>
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<tr>
<td>IGBT</td>
<td>Insulation Gate Bi-Polar Transister</td>
</tr>
<tr>
<td>IIT</td>
<td>Indian Institute of Technology</td>
</tr>
<tr>
<td>IMD</td>
<td>India Meteorological Department</td>
</tr>
<tr>
<td>IOH</td>
<td>Intermediate Overhauling</td>
</tr>
<tr>
<td>IPS</td>
<td>Intermediate Power Supply</td>
</tr>
<tr>
<td>IR</td>
<td>Indian Railway(s)</td>
</tr>
<tr>
<td>IRCA</td>
<td>Indian Railway Conference Association</td>
</tr>
<tr>
<td>IRCON</td>
<td>Indian Railway Construction Ltd.</td>
</tr>
<tr>
<td>IREEN</td>
<td>Indian Railway Institute of Electrical Engineering, Nasik</td>
</tr>
<tr>
<td>IRICEN</td>
<td>Indian Railway Institute for Civil Engineers, Pune</td>
</tr>
<tr>
<td>IRN-202</td>
<td>A type of elastic rail clip</td>
</tr>
<tr>
<td>IRPWM</td>
<td>Indian Railway Permanent Way Manual</td>
</tr>
<tr>
<td>IRS</td>
<td>Indian Railway Standards</td>
</tr>
<tr>
<td>ITI</td>
<td>Indian Telephone Industry</td>
</tr>
<tr>
<td>IVRS</td>
<td>Interactive Voice Response Services</td>
</tr>
<tr>
<td>JDR</td>
<td>Joint Director Research</td>
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<tr>
<td>JRP</td>
<td>Joint Research Projects</td>
</tr>
<tr>
<td>KRCL</td>
<td>Konkan Railway Corporation Ltd.</td>
</tr>
<tr>
<td>L.C.</td>
<td>Level Crossing</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
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<tr>
<td>LCD</td>
<td>Liquid Crystal Display</td>
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</tbody>
</table>
LED – Light Emitting Diode
LFDISP – Computer Programme for Longitudinal Force Dispersion in Bridges
LHB stock – Linke Hoffman Bush stock
LPG – Liquefied Petroleum Gas
LSPI – Lime Slurry Pressure Injection
LVDT – Linear Variable Differential Transformer; Displacement Transducer
LWR – Long Welded Rail
MACL – Multi Aspect Colour Light
MAEC - Microprocessor Applications Engineering Center
MAG welding – Metal Argon Gas welding
MBG Loading – Modified BG Loading
MEMU – Main Line EMU
MG – Meter Gauge
MIG welding – Metal Inert Gas welding
MMG Loading – Modified MG Loading
MOT - Ministry of Surface Transport
MoU – Memorandum of Understanding
MRVC – Mumbai Rail Vikas Corporation Ltd.
MSC Nastran - A software for vehicle dynamics
MSP - Measured Shovel Packing
MTR – meantime to repair
MTRC - Mobile Train Radio Communication
MW - Microwave
NCR – North Central Railway
NDT - Non-Destructive Testing
NEC – Nippon Electronic Corporation Ltd., Japan
NEI – National Engineering Industry, Jaipur
NER – North Eastern Railway
NETRA car - Network of Electrification, Testing & Recording Apparatus
NFR – North Frontier Railway
NG – Narrow Gauge
NR – Northern Railway
NTKM – Net Tonne Kilometer
NWR – North Western Railway
OFC - Optic Fibre Communication
OHE – Overhead Equipment
OMS – Oscillation Monitoring System
PBT – Polybutylene Terra
PC – Personnel Computer
PCB - Polychlorinated Biphenyl
PDH – Plesiochronous Digital Hierarchy
POH – Periodic overhauling
PPCP - Poly Propylene Co-Polymer
PQRS – Plasser Quick Relaying System
PSC – Pre-stressed Concrete
PSI – Power Supply Installation
PU – Polyurethane
PVD - Prefabricated Vertical Drain
PXE - Phenyl Xylyle Ethane
R&D – Research & Development
RAILTEL – Railtel Corporation of India Ltd.
RB – Railway Board
RBG Loading – Revised BG Loading (1975)
RCC – Reinforced Cement Concrete
RCF – Rail Coach Factory, Kapurthala
RE – Railway Electrification
RITES – Rail India Technical & Economic Services Ltd.
RMPU - Roof Mounted Package Unit
ROB – Road over Bridge
ROH – Routine Overhaul
RTRC - Railway Testing and Research Centre
RTRI – Railway Technical Research Institute
RVNL – Rail Vikas Nigam Ltd.
SAG – Senior Administrative Grade
SAIL – Steel Authority of India Ltd.
SCADA - Supervisory Control and Data Acquisition
SCR – South Central Railway
SDH – Synchronous Digital Hierarchy
SEC - Specific Energy consumption
SECR – South East Central Railway
SEJ - Switch Expansion Joints
SER – South Eastern Railway
SGAC coaches – Self Generating AC coaches
SIG contacts – Silver Impregnated Graphite contacts
SIMRAN - Satellite Imaging for Rail Navigation
SKV welding – Short Preheat Welding
SMI - Schedule of Maintenance Instruction
SNCF – French Railways
SP - Sectioning Posts
SPARMV - Self-propelled Accident Relief Medical Van
SPART – Self Propelled Accident Relief Train
SPT - Printing Vending machine
SPURT Car – Self propelled Ultrasonic Rail Testing Car
SR – Southern Railway
SRC – Supervisory Remote Control
SSDAC – Single Section Digital Axle Counter
SSI – Solid State Interlocking
SSP - Sub-Sectioning Posts
STC – A telecom equipment company of USA
SWP - Short Welded Panels
TAWD - Train Actuated Warning Device
TLMD - Toe Load Measuring Device
TMRS - Technology Mission on Railway Safety
TRALIS - Portable Track Lifting and Slewing Device
TRC – Track Recording Car
TSS - Traction substations
TTCI – Transportation Technology Centre Inc. Pueblo, USA
UFSBI - Universal Fail-Safe Block Interface
UHF – Ultra High Frequency
UIC – International Union of Railways
USFD – Ultrasonic Flaw Detector
UTS – Ultimate Tensile Strength
VCB - Vacuum Circuit Breaker
VDU – Visual Display Unit
VF communication – Voice Frequency communication
VHF – Very High Frequency
VII - Viscosity Index Improver
VVVF control – Variable Voltage Variable Frequency control
WAP Loco – BG Passenger AC Locos
WCR – West Central Railway
WILD - Wheel Impact Load Detector
WP – A type of passenger BG Steam Loco
WR – Western Railway
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6. ‘A tribute to Late Padmashri P. N. Bhaskaran Nair’ by Sri M. N. Prasad, Indian Railways Magazine, November, 2005;
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18. Indian Railways, Railway Testing and Research Centre, Asian Railway Conference, New Delhi, 1961, Published by Public Relations Department of ER on behalf of RDSO;
The book owes its existence as Sri A.K. Rao, Director General, RDSO who took the initiative to ask me, whether I would be interested to write a book on RDSO on the occasion of its Golden Jubilee year. Having served in RDSO for thirteen years in three spells and being interested in R&D activities, I readily agreed to the offer. Sri A.K. Rao has given valuable inputs which have enriched the contents and has provided full help in getting all relevant details about RDSO without which, it would not have been possible to write the book. I am grateful to him for providing the opportunity and assistance to write the book.

Sri R. Jayaraman, Addl. DG, RDSO was very helpful in providing all assistance from RDSO for the book. All the officers have willingly extended their full cooperation in providing details for writing the book. All directorates have given details of their past and present activities and achievements. Sri A.K. Kathpal, Executive Director (Engine Development) provided all coordination help from RDSO which enabled me to get all relevant information smoothly. I am thankful to him for his help and support.

I have interacted with most of the Sr EDs/EDs and some Retired Officers of RDSO and their suggestions and details provided by them have been helpful. I am thankful to all of them and would like to mention a few of them. My discussions with Sri S.K. Sinha, Sr. ED (M.P.), Sri R.K. Lal ED (Psycho) and Sri A.C. Sharma, Retd ED (Electrical) have been very useful. Sri S.M.N. Islam, CPO, RDSO and Sri Brijesh, Gupta ED (Admn) and Kamal Nayan, Director (Civil) have provided valuable support and information material. I express my sincere thanks to all of them.

Sri N.K. Tripathi, Dy Director (L&I) along with his team has willingly provided valuable details without which writing of the book was not possible in such a short time. Ms Manju Malhotra, Chief Documentation Assistant and Sri R.K. Dhingra, SLIA, Shri P.K. Katiyar, and Shri Krishna Kant, SLIA have rendered help. Ms Manju Malhotra has very good knowledge of the Central Library and provided most of the relevant literature. Sri K.K. Sharma, Photographer took pains to take relevant photographs for the book. Sri D.P. Singh, Steno (Signal) did an excellent work of typing out the script on computer in a short time. I express my sincere thanks to all of them.

Last but not the least, my wife, Sushma Agrawal, who has always supported me and stood by my side, not only exhibited extreme patience while I was busy in writing the book, she read the draft and helped with the text. I am grateful to her for her support and understanding.

Lucknow dated 5.3.07

(S.R. Agrawal)