283771/2020/O/o PED/TI/RDSO

Reasoned Document for 54MVA & 60/84/100MVA Scott Connected Traction Power Transformer Final Draft Specification

SN	Spec. Clause No.	Specification description	Comment of Firm	RDSO Remark on the comment
1.	Cover page	54MVA, ONAN 220kV/2X27kV	**M/s BHEL** The transformer is feeding (2 x27 KV) AT system. But, since there are 2 sets of two LV windings of 27 KV each in the Scott transformer (two LV windings of 27 KV each in M-phase and T-phase), the rating of the transformer should be either 200/4x27 KV or 220/2x(2x27) KV	The description may be modified as 220/2x(2x27) KV as the comment is justified
2.	Cover page	60/84/100MVA, ONAN/ONAN/ONAF, 220kV/2X27kV or 132/2X27kV or 110/2X27kV or 66/2X27kV	**M/s BHEL** Cooling of the transformer should be ONAN/ONAF/OFAF. The transformer is feeding (2 x27 KV) AT system. But, since there are two LV windings of 54 KV each in the scott transformer (one LV winding of 54 KV each in M-phase and T-phase), the rating of the transformer should be 220/2x54 KV or 132/2x54 KV or 110/2x54 KV or 66/2x54 KV	Shall be corrected in the final draft. The description may be modified as the comment is justified
3.	1.5.1.3	One outer side terminal of the secondary windings of traction transformer is connected to the catenary, the other outer side terminal being connected to the feeder. Two inner side terminals are, via series capacitors or directly, connected to each other, and their joint is solidly earthed and connected to the Traction Rails.	**M/s BHEL** There are only one 54 KV winding each in M-phase and T-phase (i.e. total 4 LV terminals taken out), with one terminal of LV winding of each phase connected to OHE and other terminal of LV winding of each phase connected to feeder. Therefore there is no inner side terminal available that can be earthed (as is available in 54 MVA scott transformer with 2 LV windings per phase). The clause may therefore be reviewed.	This Para is of the general description of the 2X25kV system. The para may be .
4.	1.6.1	Suitable air cell/separator arrangement of high quality material shall be provided in the conservator to ensure that the transformer insulating oil does not come in contact with air.	**M/s ABB** We would recommend the addition of a cell/separator leak detector to the conservator to detect cell rupture/damage or significant air leakage to the fluid side.	Firm suggestion may be accepted as it is monitoring of the aircell.
5.	1.6.2	**Oil level gauge:** It shall be of magnetic type having a dial diameter of 250mm. The gauge shall have markings corresponding to minimum oil level, maximum oil level and oil level corresponding to oil temperature of 30^0C, 45^0C and 85^0C. The oil level indicator shall be so designed and mounting that the oil level is clearly visible to an operator standing on the ground.	**M/s ABB** We would recommend the addition of low and high fluid level alarms to the oil gauge requirement. This will give warning if there is a significant loss of fluid due to major leakage and also warning if during long periods of overload at high ambient there is risk to the transformer for overpressure or rupture of the conservator cell /separator.	Firm suggestion may be accepted as it is a monitoring of the system.

6.	1.6.3	**Silica gel breather** It shall be complete with oil seal and connecting pipes. The connecting pipes shall be secured properly. The container of the silica gel breather shall be of transparent flexi glass or similar material suitable for outdoor application. Orange Silica Gel (round balls 2 to 5mm) with quantity of two DTO-8 silica gel connecting with flanged mounting two pipes control through two different valves as per DIN:42567 & IS:3401 to be provided.	**M/s ABB** We would recommend the use of: Self-Dehydrating silica gel breather. The breather shall be able to automatically regenerates the own silica gel and report the status of the regeneration through LEDs and suitable communication. The selection of suitable breather should be based on the total quantity of oil in Transformer and its application. All the external parts of the breather shall be suitable for outdoor use and & resistive to transformer oil. It should also be able to withstand the site conditions like ultraviolet rays, pollution & saline atmosphere. The breather shall be suitable to work on ambient temperature of -20°C to +80°C. The equipment must be capable to withstand all possible environmental conditions. Control box degree of protection shall be at least IP65. The type pest certificate for the same must be submitted. Breather should also be equipped with a manual regeneration button to test the regeneration functionality. Control box shall be equipped with Analogue output signal (4-20ma) for the silica gel saturation & USB / RS 485 port for downloading the operational data logged by the unit. Required software supporting the analog and digital functions shall also be provided. Supply of Laptop/PC for above software is not envisaged.The equipment shall operate at input supply of 230V AC, 50 Hz. Any converter if required shall be supplied with the equipment. The breather shall also be equipped with suitable protection against overvoltage. Type Tests reports must be submitted for offered breather. The supply shall have a minimum 5-year manufacturing experience and minimum 2 performance certificate of more than 1 year of successful operation shall be available from state / central Indian utility 1. No need of replacing silica gel for minimum 10 Years 2. No silica gel visual inspection, replacement & disposal. 3. Full control of drying agent saturation status. 4. SCADA connectivity for signals displaying the silica gel saturation level. 5. No environmental impact for silica-gel disposal 6. Total cost of ownership reduction.	Firm suggestion of self-dehydrating breather may be accepted as an optional requirement in the specification, so that for any remote or very humid location, it can be utilized by Indian railways, if required.
7.	1.6.4	**Pressure relief device:** It shall be designed to operate to release internal pressure at preset value without endangering the equipment or operator and shall	**M/s ABB** Given the very frequent occurrence of short circuits and overloads, we recommend the use of a smart pressure relief valve. The PRD shall be capable of continuously indicating the pressure in	Firm suggestion may be accepted as an optional requirement with the conventional PRV, since the

		be of instantaneous reset type. Shroud Pressure relief Device will be used and have provision of discharge of oil from PRD to safe place by closed pipeline. This avoids hazards of fire and it is safe to persons working near Transformer & it is environmental friendly.	main tank through 4-20mA analog communication. The PRD shall have provision of digital communication through Modbus or similar protocol. This shall be suitable for integration with SCADA if required. Also, if required PRD should be capable of giving soft alarm in system. This device detects and reports pressure increase as well as pressure relief valve operation. Evolving problems due to frequent short circuits may possibly be detectable well prior to tripping of transformer and the need for unexpected outage avoided. Also, the possible discharge of oil may be avoided.	manufacturers of smart PRV are limited in India at present, it is mainly imported item.
8.	1.6.8	**Buchholz relay:** It shall be of double float type, with two shut - off valves of 80 mm size, one between the conservator tank and Buchholz relay and the other between the transformer tank and Buchholz relay. The relay shall have one alarm contact and one trip contact, none of the contacts being earthed. The contacts shall be magnetic switch or micro switch type, electrically independent and wired up to the marshaling box. A testing petcock shall be brought down through a pipe for the purpose of sampling the gas, if any, collected in the Buchholz relay.	**M/s ABB** Given the very frequent occurrence of short circuits and overloads, we recommend the use of a smart gas pressure relay (Buchholz relay). Along with the conventional features, Buchholz relay shall be suitable for remote indication of the parameters being measures as defined below. a) The Buchholz relay shall be capable of continuously communicating the oil level through 4-20mA analog output. b) The Buchholz relay shall have provision of digital communication through Modbus or similar protocol. This shall be suitable for integration with SCADA if required. The protection class of Buchholz relay shall be at least IP65. This device detects and reports accumulating volume of gas as well as normal Buchholz functions. Evolving problems due to frequent short circuits may possibly be detectable well prior to traditional alarm and tripping of transformer and the need for unexpected outage avoided.	Firm suggestion may be accepted as an optional requirement with the conventional Buchholz, since the manufacturers of smart Buchholz relay are limited in India at present, it is mainly imported item
9.	1.6.10	It shall have one alarm contact, one trip contact, two contacts for FAN operations and two normally open spare contacts, none of the contacts being earthed.	**M/s HighVolt** (For 54MVA, 220/27kV Transformer Only) It will not have contacts for FAN operations as this transformer are naturally/air cooled & no cooling fan.	Firm comment is accepted in view of the justification by the firm and clause shall be modified.
10.	1.6.12	Thermo Siphon Filter System is to be provided for absorbing the moisture present in the insulating oil with the natural convection. The full details for installation and subsequent maintenance have to be furnished to RDSO and the consignee	**M/s Prime Meiden** We recommend to remove the requirement of Thermo Siphon Filter, as this is not necessary, since, entry of moisture into the tank does not take place because the conservator is fitted with AIR Cell type OIL preservation system. This system ensures that there is no direct contact of Transformer Oil with external atmosphere. Thermosiphon filter system is an obsolete system that was used by many Indian utilities earlier,	Comments of the firms may be accepted to remove the requirement of the thermo syphon filter as the Aircell has been added with the transformer.

			where well established air cell type oil preservation system were not in place **M/s ABB** We recommend exclusion of this clause. In case specifically required we recommend use of online transformer oil drying system which is universally accepted and are more reliable. Thermosyphon Filters are primitive solution which does not find much relevance with improved design and use of air cell.	
11.	1.6.14	**Fibre Optic Winding Hot Spot Temperature Monitor:** Fibre optical winding hot spot temperature monitor to be provided with the transformer windings, connected in addition to the winding temperature indicator in parallel to measure transformer winding hot spots in real time and activate control of the cooling system. The Fibre to be given high strength casing through jacketing and Fibre Optic shall be governed by IEC-60076-2 (Ed.3.0)	**M/s ABB** We recommend that the fibre optics are also used to monitor the hotspot temperature in service to validate the effects of harmonics. Additionally, the temperature rise information (with and without harmonics) from a design review meeting together with the FAT fibre optic results (without harmonics) should be used: • To set the winding temperature indicator to simulate hotspot gradient with harmonics • Determine if the transformer FAT results meet the allowable temperature rise limits for the service situation with harmonics.	The Fibre optic winding Hot Spot temperature is kept functional during the Type Testing and is also functional on the site also. No change in the specification is required in view of the firm suggestions.
12.	3.2.1	The tank for the transformer shall be of the top cover jointed with bolted connection. The bottom plate of main tank shall be firmly welded to the main body and the top cover is a plate reinforced with ribs. The winding and core shall fully exposed when the tank cover is lifted. A pressure gauge along with a hygrometer shall be provided so that the status of dryness of the winding can be assessed in the transformer prior to its heat run before commissioning.	**M/s Prime Meiden** We recommend to delete the "The winding and core shall fully exposed when the tank cover is lifted" and "A pressure gauge along with a hygrometer shall be provided so that the status of dryness of the winding can be assessed in the transformer prior to its heat run before commissioning" as strict humidity control policy is followed during production by all the reputed Transformer manufacturers. **M/s ABB** The tank for the transformer shall be of **Conventional** type construction with flanges on the outside and shall have a flat top .The flanges of the upper and lower tanks shall be joined by bolts, nuts and suitable plain/spring/beveled washers. A suitable gasket and metallic stoppers shall be provided between the flanges of upper and lower tank so as to prevent leakage of Insulating Oil. The tank shall be so designed that the winding and core get fully exposed when the bell tank cover is lifted. As per Clause 6.1 of recent CBIP manual, ***"All transformer reactor tanks should generally be of conventional type"***. The Bell tank is not generally recommended. It is asked only if there is a facility limitation to lift the	As per CBIP manual on transformer issued in April 2013, publication no. 317 - "All transformer reactor tanks should be generally be of conventional type i.e. tank body with top cover, Bell shaped construction can be specified for 100MVA and higher rating transformer unless otherwise mutually agreed between Purchaser and Manufacturer. This manual does not make a mandatory requirement for the bell tank below 100MVA, Also this transformer is of 100MVA. Considering the possibilities of the overhauling of the

			active part for full inspection purpose. ABB recommends not to expose the active part to the atmosphere and thus bell type tank is not recommended. Also, there could be hot spots on bolts at the curb of bell and the damage to the gaskets can cause leakage in long term operation. The oil head is also more at the curb joint in case of Bell type tank which also increases the chances of oil leakages. **M/s BHEL** Tank is specified with top cover and to fully expose core& coil with cover lifted. Please clarify whether the tank is bell type construction (as in 54 MVA scott transformr specification) or conventional type. Hygrometer is not applicable for the transformer. Hygrometer has never been supplied for any of the transformers even up to 400 KV transformers. Dryness of the transformer is ensured by well-established processes during the manufacturing and testing. Hygrometer is therefore not required. Pressure gauge on tank is also not applicable and not required.	transformer at the site, the bell type transformer tank has been used in the Indian Railways, and thus the bell type tank is recommended for this rating also.
13.	3.2.4	The tank shall be fitted with an under carriage and mounted on eight bi-directional swiveling type flanged rollers for being rolled on 1676 mm (5' 6") gauge track on which it shall also rest in the final position	**M/s ABB** We would recommend that 4 bi-directional rollers is sufficient for a transformer of this size **M/s TBEA** Four/eight rollers shall be used based on the size and weight of the transformer.	Eight rollers to be provided as per the specification considering for the easy movement of transformer at the TSS location when required.
14.	3.2.6	The rubberised cork/gaskets used in the transformer shall conform to IS: 4253 (Part - II).	**M/s TBEA** We propose to use Nitrile Butadiene rubber as it has better performance over SRBC gasket.	or equivalent/better may be mentioned in the specification
15.	3.4.1	The core shall be built from high permeability Cold Rolled Grain Oriented (CRGO) silicon steel laminations conforming to IS: 3024. The flux density in any part of the core and yokes at the principal tapping with primary winding excited at the rated primary voltage and frequency shall not exceed 1.7T.	M/s Toshiba The core shall be built-up of high permeability cold rolled grain oriented silicon steel laminations conforming to JIS C2553 or equivalent IS as indicated in Table No. 2.1-1.The flux density in any part of the core and yokes at the principal tapping with primary winding excited at the rated primary voltage and frequency shall not exceed 1.7 T. **M/s ABB** We would recommend that the normal flux density is limited to 1.7 T rather than 1.55 T. The core steel grade used should have tested single strip loss results at 1.7 T (50 Hz) less than 1.25 W/kg. Additionally, in order to avoid local heating and flux concentration, the core should use step lapped core joints and laminations should not have holes such as for manufacturing alignment	In the specification already 1.7 Tesla is mentioned which is as per the comments, so no change is required. JIS is Japanese standard, since the IS is available for the item, the standard of any other country cannot be mentioned in view of the 'Make in India' concept. Comment of M/s ABB that "Indian transformer manufacturers shall

			nor have bolts (insulated or otherwise) through the laminations. The Bidder shall submit the Flux Density Calculation along with the design review and the same specified parameters shall be verified during physical stage inspections by methods as specified in the stage inspection procedure. Indian transformer manufacturers shall use core material as per above specification with BIS certification. Modern core steels have a saturation flux density > 2.0 T. Hence normal flux densities of 1.7 T are still very safe. Even with system highest voltage applied continuously to the transformer, the flux density of 1.89 T is comfortably below saturation and excessive heating. This is provided a modern core design is used with step lapped joints and no lamination holes or through-bolts giving local flux concentrations. The use of the modern steels can be assessed with submission of typical B-H curves and assessment of the core exciting current at tender and factory assessment testing stages. We can offer some suggestions/information on this via our application engineering team if it is of interest. **M/s TBEA** We understand that this is because of tap on primary for primary variation**.**	use core material as per above specification with BIS certification" may be added in the specification to ensure quality. As per CBIP manual on transformer issued in April 2013, publication no. 317, Para no. 2.9.1 (page 11), Maximum Flux Density shall not exceed 1.9 Tesla. In addition to these, the use higher flux density will have advantages that it shall reduce the size of the transformer which shall be beneficial to Indian Railways for space saving for the TSS. Considering the above and reason mentioned by the firm, the comment of M/s ABB may be accepted in view of the reasons mentioned. In the specification it may be mentioned as flux density shall not exceed 1.7T. Comment of M/s ABB that "Indian transformer manufacturers shall use core material as per above specification with BIS certification" may be added in the specification to ensure quality. .
16.	3.4.3	The core shall be electrically connected to the tank.	**M/s ABB** We recommend that the core, core clamps and tank should be insulated from each other with a	Firm comment may be accepted for adding in this para. Already in

			single location conscious earth connection. The insulation shall be high temperature, non-deteriorating (non-cellulose) material. The earth connection shall be accessible without draining any oil, behind a cover-plate to allow the connection to be opened for testing of the insulation resistance at 2.5 kV. This will ensure that the core is earthed in service at one point only to avoid any possible circulating currents. It also allows the insulation integrity to be verified periodically during POH or in response to adverse DGA signatures. For a transformer that is subjected to frequent short circuits, this arrangement is recommended.	the specification 2kV insulation test is mentioned between core laminations and core clamping bolts.
17.	3.4.6	Manufacturer shall, preferably have the core cutting facility in their works and proper monitoring and quality control to avoid any mixing with defective /second grade materials.	**M/s ABB** We recommend that it is not necessary to have the core cutting facility at the manufacturer's works if the appropriate monitoring and quality control systems are in place. We recommend adding a requirement to perform and analyse a core resistance test across the lamination steps of the completed core to assess for this. This will ensure that the core is earthed in service at one point only to avoid any possible circulating currents. It also allows the insulation integrity to be verified periodically during POH or in response to adverse DGA signatures. For a transformer that is subjected to frequent short circuits, this arrangement is recommended.	As per the specification it is not a mandatory requirement, so any change is not required in the specification. The no load losses are already defined in the specification, which are measured during the routine testing of the each job. For addition of CORE resistance test any reference standard has not been linked with the comment, so cannot be accepted.
18.	3.5.1	The winding shall be of concentric disc or interleaved for the primary, and disc or helical/cylindrical for the secondary windings. The four terminals of both secondary windings of 'M' and 'T' phases shall be brought out separately through 54 kV OIP condenser bushings.	**M/s Toshiba** The winding shall be of disc/interleaved/inter-shield/rectangular pancake type for the primary and of disc/helical/cylindrical/rectangular pancake type for the secondary windings**.** **M/s ABB** We recommend that the winding type be changed to: The windings shall be of an axially clamped concentric winding design. Windings shall not be multi-layer type which rely on epoxy dot bonding to interlayer paper/pressboard cylinders to maintain short circuit axial force withstand. Winding types shall be axially clamped disc, helical or single/double layer types of substantial radial depth. Due to the very frequent short circuits, it is necessary to have windings with substantial radial dimension and are firmly axially clamped. Distribution transformer type multilayer windings	As per the specification transformers design is accepted which passed all the type test including the dynamic stability short circuit test in a laboratory, the design is not accepted on the basis of the theoretical calculations. Therefore, the type of the transformer winding may be decided by the transformer manufacturer after ensuring that the all

			using diamond dot interlayer papers to bond to the turns for axial force withstand are not secure enough for this transformer duty.	the parameters mentioned in the specification are fulfilled with that design. The clause shall be modified accordingly.
			M/s BHEL There is no 54 KV system voltage. 52 KV OIP bushing for LV as specified in clause 3.7 shall be provided.	For 55kV windings, the requirement of 60kV Bushing may be mentioned in the specification.
			There are 2 LV windings (one each in M-phase and T-phase) of 54 KV with total 4 LV terminals taken out. We understand the two LV windings shall feed OHE and feeder independently and shall not be cascaded (unlike 54 MVA scott transformer that has 2 LVs in each phase casdaded (with 8 terminals taken out)). The clause may be reviewed.	Clause shall be modified in the specification
19.	3.5.2	The windings shall be made of continuous electrolytic copper conductor, paper insulated to class - A insulation. The conductor shall not have sharp edges which may damage the insulation.	**M/s ABB** Thermally upgraded insulation, while still class A material has a better thermal lifetime performance. For a transformer that is subject to high levels of harmonics, the winding hotspot is at risk of higher values and more sensitive to increased harmonics. Thermally upgraded paper is more resistant to the impact of the higher winding hotspots. Epoxy bonded continuously transposed cable which includes enamelled strands is particularly suitable for transformers with harmonics and high short circuit demands. Its small strands are helpful to reduce the increased eddy losses from the harmonics while the epoxy bonding of the strands dramatically increases the short circuit withstand strength.	As pre the IS: 2026 (Part:14): 2018, Para 3.6, Thermally upgraded paper is cellulose-based paper which has been chemically modified to reduce the rate at which the paper decomposes. Also as per the para 5.6 of IS:2026 Part – 7, The purpose of thermally upgrading insulation paper is to neutralize the production of acids caused by the hydrolysis (thermal degradation) of the material over the lifetime of the transformer. This hydrolysis is even more active at elevated

				temperatures, and published research results indicate that thermally upgraded insulation papers retain a much higher percentage of their tensile and bursting strength than untreated papers when exposed to elevated temperatures. In view of the above, The comment to use thermally upgraded paper may be accepted. Option for epoxy bonded continuously transposed conductor shall also be added in the specification, since for normal single phase transformers CTC conductor are already being used by RDSO approved vendors from many years.
20.	3.5.3	Normally, no joint shall be used in the winding conductor. If a joint becomes inescapable, it shall be brazed with high silver alloy grade BA Cu Ag6 conforming to IS: 2927 or electrically butt - welded.	**M/s High Volt** Winding conductor should not have any joint.	Already in the specification it is mentioned that normally no joint shall be used, if it is made compulsory in the specification, it has to be verified by the inspector during the stage inspection, which is not possible after complete winding, so no change in specification is required.
21.	3.5.9	The axial pre - compression on	**M/s ABB**	As per the

		the windings shall preferably be double the calculated axial thrust that may be set up under dead short - circuit condition so as to ensure that the windings do not become loose due to frequent short circuits in service.	We recommend that: The short circuit withstand can be determined by either: 1. Winding dynamic force response to the electromagnetic field calculations for this specific design. 2. Electromagnetic field calculations alone with standardised dynamic response factors. It is strongly preferred that the short circuit withstand is based on the design specific dynamic response behaviour method. For dynamic for calculations: The transformer short circuit withstand should be preferably analysed and demonstrated using and including: Dynamic force response calculations derived from electromagnetic leakage field plots. The dynamic response calculations shall be specific to the windings of this transformer. The dynamic response is to account for the compressible nature of the insulation materials within and outside the windings. Winding offsets to account for manufacturing tolerances and errors Winding offsets to account for the pitch of any helical or layer windings Determination of winding resonant frequencies which should not coincide with 50 Hz or its multiples. The axial pre-compression force for the windings shall be based on the maximum axial dynamic response and the minimisation of mechanical stress in the system. To account for the high frequency of short circuit events, the allowable withstand stresses shall be reduced to 80% of the normal material withstand levels. For electromagnetic field only calculations: If the transformer short circuit withstand is not analysed with the individual design specific dynamic force response then the forces shall be determined by use of electromagnetic field plots which also include: Winding offsets to account for manufacturing tolerances and errors Winding offsets to account for the pitch of any helical or layer windings. The electromagnetic forces from the field plot shall be increased by a factor of 1.5 to account for the dynamic winding response. The axial end force shall be the greater of the 1.3 times the electromagnetic end forces or the peak axial compression force within the winding.	specification, the dynamic stability of every design is tested by the short circuit test in a laboratory, the design is not accepted on the basis of the theoretical calculations. Also, the suggestion of the firm has not been supported by any national or international document, thus in the specification it is not feasible to incorporate. . Also, the suggestion of the firm has not been supported by any national or international document, thus in the specification it is not feasible to incorporate.

			Additionally, the stresses so determined shall not exceed one third of the material maximum permissible stresses or 50% of the allowable withstand levels given in IEC 60076.5, whichever is lower. The axial pre-compression of the windings will be significantly higher than double the end thrust due to the electromagnetic force calculation. This is due to the dynamic nature of the short circuit forces and hence the "bounce back" reaction forces from the windings. For geometrically balanced windings, the electromagnetic forces at the ends appear relatively small but the actual resultant dynamic forces are much larger. While these are sometimes estimated by experience, for transformers subject to frequent short circuits, it is necessary to perform an actual dynamic force calculation for the specific windings of this transformer and design accordingly. Please see the comments in the general recommendations about short circuit withstand integrity. We would be pleased to offer our application engineering team to deliver some technical training on short circuit withstand of power transformers including "self-supporting" windings behaviour, dynamic force calculations and learnings for short circuit testing	
22.	3.5.10 3.5.20	During short circuits, the stresses actually set up in conductors, spacers, end blocks, clamping rings and such other parts of the transformer shall not exceed one third of the maximum permissible values.	**M/s ABB** Given the Annexure 4 force calculation expected accuracy, we can understand the very low 33% withstand limit. Typically, modern practice would determine forces via electromagnetic field plots and dynamic oscillation factors. For transformers with this high frequency of short circuit events we would recommend that the winding dynamic response is directly calculated for this individual design and the resonant frequencies are determined and controlled. Given this much more accurate, well proven approach the stress limitations can be increased substantially. Inner windings experience radial buckling forces that include free buckling modes of failure. These are often the lowest withstand mode of radial failure. Such free buckling failures are independent of the number or spacing of mechanical supports inside the winding. Additionally, any supports that are tight inside the winding when new will shrink over time with the normal thermal aging of the transformer	As per the specification, the dynamic stability of every design is tested by the short circuit test in a laboratory, the design is not accepted on the basis of the theoretical calculations. Also, the suggestion of the firm has not been supported by any national or international document, thus in the specification it is not feasible to incorporate.

			insulation. Hence, they will no longer remain tight throughout the transformer life. For these reasons, we believe it is essential to design the windings to be "self-supporting" against radial failure and not rely on the inner supports for short circuit withstand. Supports are in place for transport and geometry and cooling performance control but not for short circuit withstand. This is especially import for transformer with heavy and high frequency short circuit duty.	
23.	3.5.14	In order to cater for shrinkages that may occur in service, substantial clamping rings shall be provided at the tops of the windings, being pressed down upon them by means of adjustable pressure screws or oil dash pots or any other suitable device, so as to maintain a constant pressure and obviate the need for any retightening in between successive periodical overhauls.	**M/s ABB** Our understanding of this clause is that uniform clamping force and uniform axial dimension is required upon the whole circumference of the coil or set of coils during pressing before and immediately after the dry out process.	No remarks required.
24.	3.5.15	The coil and core assembly shall be retightened after oil impregnation. The manufacturer shall ensure that there is no further shrinkage of the coil assembly in any additional cycle after the final curing.	**M/s ABB** We recommend that an additional alternative process could be considered: If the core and coils are vapour phase dried to less than 0.4% moisture and it can be demonstrated with data records that the manufacturing systems and controls are sufficiently strong then the final tightening post impregnation may be deleted.	The specification mention the requirement that there shall be no further shrinkage, comment is a manufacturing procedure practice which manufacturer to ensure, no need to add in the specification.
25.	3.5.17	The core and winding of the transformer have to be dried preferably using Vapour Phase Drying (VPD). To ensure the removal of moisture from the transformer the PI value after drying has to be achieved equal to or more than 2 (two) in the manufacturing at the works	**M/s ABB** We recommend that vapour phase drying is used and either the moisture level of a sample block from the vapour phase or later DFR (dielectric frequency response) measurement is used to demonstrate that cellulose moisture content is <0.5%. We would not recommend that PI >2 for moisture assessment criteria for a new transformer in the supplier's factory. It is not a sensitive measure for this new transformer stage. Additionally, modern, good quality, new transformer oils often have very high resistivity and this results in PI < 2 even for very dry, clean, high resistivity transformers. PI should be measured as a benchmark only for future PI measurements.	The measurement of PI can be done the inspector during the testing of job, the cellulose moisture content measurement can be done at the manufacturing stages by the manufacturer itself, it is not needed to make it a part of the specification.
26.	3.6	The transformer shall be	**M/s Toshiba**	Indian Railway is using

		supplied with new Inhibited Mineral Insulating Oil conforming to IS: 335:2018 (Type-II) and the additional requirements stipulated under clause 6.3.8.9. In addition 10% extra oil by volume shall be supplied in non-returnable steel drums. The characteristics of the insulating oil before energisation of the new transformer and during its maintenance and supervision in service shall conform to IS: 1866.	The transformer shall be supplied with new insulating oil conforming to IEC60296. In addition, 10% extra oil by volume, shall be supplied in nonreturnable steel drums. The characteristics of the insulating oil before energisation of service shall conform to IEC 60296.	the Insulating Oil as per the Indian Standard in the conventional single phase traction transformers, auxiliary Transformer, CT, PT, same can be used for this also, no need to change.
27.	3.7 3.7, 3.7.1 3.7.3 3.7.4	Porcelain type OIP Condenser bushing	**M/s ABB** We would recommend that dry type condenser bushings are used employing resin impregnated paper or synthetic material rather than OIP condenser bushings. This will significantly reduce the safety risk of a possible fire. We would also recommend the use of polymer shed on the outdoor side of the bushings rather than porcelain. For the 12 kV bushings we recommend that solid moulded resin/polymer bushings are preferable for the same reasons as given for the Dry type condenser bushings. RIP/RIS bushings if damaged or if subject to internal failure tend to act as a plug maintaining a seal for the transformer oil away from the atmosphere. This reduces the risk of fire. OIP bushings tend to shatter, fall into the transformer internals and leave an opening to the atmospheric oxygen into the transformer and hence fire risk. The polymer sheds are much less fragile than porcelain and hence less likely to be damaged or shatter. Additionally, in the event of a bushing failure the explosive velocity of porcelain shrapnel is a high risk for personnel injury/death. The polymer sheds do not shatter and remove this risk entirely.	The use of Dry type bushings is a separate policy decision can be decided separately when the sources of Indigenous make are easily available.
28.	3.7.2	Current Rating of the Bushing	**M/s BHEL** Current of 52 KV LV side bushing in clause 3.7.2 is mentioned as 3150 A while in clause 5 point 19, the current is mentioned a 1250 A. The same may be reviewed and revised.	Shall be corrected in the final draft
29.	3.7.7	Adjustable arcing horn shall be provided on both the primary and secondary bushings.	**M/s ABB** We recommend replacing arcing horns with surge arresters as per modern practice	Arcing Horn and surge arrester both are provide in Indian Railways.

30.	3.10	Tap Changer	**M/s BHEL** We understand that the tap changer is motorized off circuit tap changer.	Yes, the tap Changer is motorized off circuit tap changer, which is already mentioned in the specification
31.	3.11.3	In case of use of headers, isolating valves of size 80mm shall be used between tank and headers.	**M/a TBEA** In case of use of headers, isolating valves of size 80mm (minimum) shall be used between tank and headers.	Firm comment may not be accepted as any specific size with reason has not been commented. Also, a standard size is required to be specified for uniformity in all the transformers of same rating.
32.	5.2 (4)	Rated current (for 54MVA)	**M/s BHEL** In the formula for current calculation the MVA rating shall be 13.5 instead of 30 MVA (i.e 13.5/27*1000 = 500 A) – for 54MVA	Shall be corrected in the final draft
33.	5.2 (7)	Windings (for 54MVA)	**M/s BHEL** The clause describes "Two secondary windings, one per phase…" while the transformer has 2 set of 2 x 27 KV secondary windings. The desciption as per the clause 5, point 2 of specification ETI/PSI/124(07/95) may be retained.	Shall be corrected in the final draft
34.	5.2 (10)	For 54MVA; Percentage Impedance : Maximum value of Percentage Impedance at 30MVA base at principal tapping	**M/s BHEL** The percentage impedance is specified at 30 MVA base. The base of percentage impedance may be corrected to 13.5 MVA We understand that the impedance (12 ± 1.2) % is between each pair of winding i.e HV/LV1 & HV/LV2 of Main phase and HV/LV1 and HV/LV2 of teaser phase at 13.5 MVA base at principal tap.	Shall be corrected in the final draft. The details for measurement shall be mentioned in the final draft
35.	5.2 (14)	For 54MVA; Temperature rise: Top oil: 40 ^{0}C	**M/s BHEL** Top oil temperature rise may be limited to 45 °C in line with the specification TI/SPC/PSI/TRNPWR/6200 for 60/84/100 MVA Scott transformer	The 54MVA Scott transformer with the 40 ^{0}C limits are already in service in IR. For 100MVA, 45^{0}C was mentioned. Comment is not accepted.
36.	5.1(5)`	No-load losses, kW =50 kW Total load losses at the principal tapping=200 kW at 60 MVA ONAN Total loss, kW =250 kW	**M/s Toshiba** No-load losses, kW =55 kW at 60MVA ONAN Total load losses at the principal tapping=195kW at 60 MVA ONAN Total loss, kW = 250 kW 60MVA ONAN **M/s BHEL** Maximum permissible load loss of 240 KW at 60 MVA	Considering the suggestions the clause may be modified as No-load losses, =55kW Total load losses at the principal tapping=240 kW at 60 MVA ONAN

				Total loss, kW =295 kW
37.	5.1 (10)	Percentage Impedance for 60/84/100MVA	**M/s BHEL** We understand that the impedance is between HV/LV of Main phase and HV/LV of teaser phase at 30 MVA base at principal tap. The description of impednce may be revised accordingly.	For clarity the description shall be modified in the final draft.
38.	5.1(19)	Acoustic sound level when energized at rated voltage and at no-load	**M/s BHEL** We understand that the noise level specified is for 60 MVA ONAN rating (i.e without fan and pump running).	Shall be clearly mentioned in the final draft
39.	5.1(14)	The temperature rise over an ambient temperature of 50^0C both at rated and overload conditions shall not exceed the value indicated below: 1. Winding: 50 ^{0}C at rated load, and 60 ^{0}C for overloads as specified in Clause 5.1.1(11) (temperature measured by resistance method). 2. Top oil: 45 ^{0}C (temperature rise measured by thermometer). 3. Current carrying parts in air: 40 ^{0}C (temperature rise measured by thermometer).	**M/s ABB** We recommend that the specification of winding hotspot temperature rise limits should be added to this clause. If the more modern aspects of winding gradient hotspot factors recommended for Clause 6.3.1.2 are included and consideration included for the effects of harmonics plus the use of fibre optic probes measured hotspot results are included, then we would recommend the following revised temperature rise limits: At Rated load (with harmonics included): Top Oil Temperature rise = 50 C Average winding Rise (by Resistance) = 55 C Winding Hotspot Rise = 68 C via the highest of techniques in comments for Clause 6.3.1.2 At Overload (with harmonics included): Winding Hotspot Rise = 80 C via the highest of techniques in comments for Clause 6.3.1.2 We would be pleased to explain the background and basis of these recommendations via a video conference discussion with our application engineering team.	The winding hotspot temperature rise limits is already mentioned in the other clause, may be mentioned in this clause also. The temperature rise limits are verified during the type testing of the transformer which is conducted at the works of the manufacturer, not at TSS location. The requirements mentioned in the specification are sufficient.
40.	5.1 (15)	Ability to withstand short circuit Thermal ability: 5 s Dynamic ability : 0.25 s	**M/s Prime Meiden** We recommend the Ability to withstand short circuit of Thermal ability of 2[sec], based on our designed and supplied experience. In case of requirement of 5[sec], it will lead to costly Transformers. **M/s Toshiba** The short circuit test shall be conducted at 60MVA in accordance with IS 2026(part-I) or IEC IEC 60076-5.Thermal ability : 2 s; Dynamic ability : 0.25 s **M/s ABB** We recommend changing duration for dynamic short circuit test from 0.5 seconds to 0.25 seconds as per standards	For dynamic stability, in the IS: 2026-2011, part-5 (para 4.2.5.5), the duration of 0.25second is mentioned for dynamic stability and for thermal stability in Para 4.1.3 it is mentioned that the duration of the current I to be used for the calculation of the thermal ability to withstand short circuit shall be 2 s unless a different duration is

			M/s BHEL Dynamic ability to withstand short circuit as per IS: 2026, IEC 60076 is 0.25 sec. The Dynamic ability to withstand short circuit may be revised as per the standards.	specified. The para in the Final Draft may be modified.
41.	5.1(16)	Flux density at rated voltage and frequency at principal tapping Shall not exceed 1.7 tesla	M/s ABB We recommend that the flux density limit should be 1.7 tesla.	Already in specification 1.7 limit is mentioned.
42.	5.1(17)	Current density in the windings at rated current shall not exceed 2.5 A/mm2 at 60MVA for ONAN	The suggested current density limit is very low. We recommend that this limit is removed. The Current Density Limit of 2.5 A/mm2 is very low. This low limit is not necessary with modern power transformer design. Such a low limit would only be considered for older type distribution type transformer multi-layer windings without cooling ducts. For power transformer clamped windings with disc and helical windings much higher current densities are readily suitable. More importantly, the cross-sectional area and current density should be determined by correct short circuit withstand strength and suitably limited winding hotspot gradients in the presence of the stated harmonics. Suggestions for these characteristics are given in other comments	The requirement mentioned in the specification is a preferably requirement not a mandatory requirement. So no change is required in the specification. For any Indian Railway Transformer the design of the transformer is verified by the short circuit, temperature rise test, load loss, no load loss & impedance tests, so manufacturer may use the density as per their need suitable for their winding type.
43.	5.1(18)	Acoustic sound level when energized at rated voltage and at no-load. Not more than 75 dB at a distance of one meter.	M/s Toshiba NEMA Standard TR-1-1993 (R2000) Table -2	Any reference value has not been suggested by the comment; no change in specification is required.
44.	5.1(20)	The bushing type current transformers shall be tested in accordance with IS: 2705 (Part-I & IV) or IEC: 60044-1.Class of accuracy as per IS:2705 (Part IV) or IEC 60044-1=PS	M/s Toshiba The bushing type current transformers shall be tested in accordance with IEC60044-1.Class of accuracy as per IEC60044-1=PX	Since the Indian Standard in available, the mentioning of IEC is not required considering the 'Make in India' concept.
45.		K=309(I+0.25C).I=Max. NLL in Watt and C= Max. Load loss in Watt	**M/s Toshiba** Capitalisation of Transformer Losses : Not Applicable	The comment of the firm is not accepted, the capitalization is calculated to evaluate the cost of the transformer in Indian Railways.
46.	6.2.1.3	Pressure test: Every transformer tank, radiator and conservator tank shall be	M/s ABB We recommend that the "air pressure test" should be replaced with "pressure test". Ie do not	The firm comment is not accepted. The air pressure test

		subjected to an air pressure corresponding to twice the normal static head of oil or to the normal static head of oil or to the normal static oil head pressure plus 35 kN/m^2 (0.35 kgf/cm^2), whichever is lower, as measured at the base of the tank. The pressure shall remain constant for 1 h to indicate that there is no leakage.	perform the test with a vessel full of compressible gas. Alternatively, this test could be deleted and only rely on the test in Clause 6.2.1.1 which is of the same pressure levels. Performing a pressure test with the vessel filled with gas can be dangerous as the energy stored in the large volume of compressible gas is very large. In the event of an unexpected rupture there can be a dangerous "explosive" style release of energy. The pressure test is best performed with the vessel filled or almost filled with liquid (incompressible) and the overpressure is applied to a small gas space above the liquid. The stored energy is then dramatically reduced making the situation non-dangerous. This will also allow the test to also simulate the normal static pressure head profile of pressure making it more representative of the real service environment.	should be conducted on the transformer tank during the manufacturing stage, so that any leakage, if there, can be rectified. If only oil leakage test is mentioned, which is done final stage, It will not easy to rectify that.
47.	6.2.2.3	Transformer Tank: following tests shall be conducted: (i) The pressure test and vacuum test shall be done as per the clause no. 6.2.1.2 & 6.2.1.3 of this specification. (ii) The Dye Penetration (DP) Test at the jacking and lifting pads.	**M/s ABB** A cumulative core resistance test across the stacked height of the laminations of the completed core could be added to this clause. This would allow assessment of core steel insulation quality throughout the core as well as edge burr suitability.	The suggested test is for manufacturing stage test which is not done on each job moreover, if any test is added in the specification, its acceptance limits has to be specified, already no load losses are mentioned, it is not required.
48.	6.3.1.2 item2	The ambient temperature shall be measured using alcohol in glass thermometers only.	**M/s ABB** We recommend that measurement of ambient temperature by use of thermocouples or electronic thermometers is also allowed. The more modern, accurate and safer practice of measuring ambient temperature is via the use of thermocouple or electronic thermometers. This allows remote and even continuous readings to be taken without endangering personnel to the transformer under test	The firm comment is accepted as per the latest measuring practices being followed during the testing.
49.	6.3.1.2 (1)	Temperature rise test shall be undertaken at transformer on ONAN, ONAF and OFAF ratings	**M/s BHEL** Overload of 150% for 15 min & 200% for 5 min is specified on ONAN rating only as per clause 5 point 11. Temperature rise test shall be done at full load (100% load) for ONAN, ONAF & OFAF rating. However, for overload the test shall be applicable for ONAN only. Please specify/change the clause accordingly	Shall be clarified in the final draft specification.
50.	6.3.1.2 item6	The temperature of the hot - spot in the winding shall be the sum of the temperature of the	**M/s ABB** We recommend that the winding hotspot should be based on K*H *(the temperature rise of the	The suggestion of the firm has not been supported by any

		top oil and 1.1 times the temperature rise of the winding above the average oil temperature.	winding above the average oil temperature), where K is the maximum of • 1.3 • The design review meeting demonstrated value of hotspot factor (50 Hz) • The temperature rise test measured value derived from the fibre optic probes H is the increase in hotspot gradient due to the service harmonics as established at the design review meeting and the winding information The winding temperature indicator should be set in accordance with the values above. Modern International standards recognise and give guidance that hotspot gradient factors are significantly higher than 1.1, typically at least 1.3 is considered appropriate but up to 1.6 is not unusual depending upon the design details. Here, the measured hotspot factor at 50 Hz can be determined via the use of the included fibre optic probes. Additionally, for transformers that are subjected harmonics, the hotspot factor will be significantly increased. This harmonic increase can be determined from the FAT 50 Hz fibre optic results plus knowledge from a design review meeting of the winding details and harmonic levels	national or international document, thus it is not feasible to incorporate in the specification.
51.	6.3.1.3.1 item1	A quantum of power equal to the sum of the measured losses viz. No- load loss and load losses measured at lowest tap position, corrected to 75^0C plus 10% of such sum shall be fed to the primary winding of the transformer with the secondary windings short- circuited.	**M/s ABB** We would recommend that the load losses supplied should be the measured 50 Hz load losses (corrected to 75 C) plus the additional losses equal to the additional eddy losses from the service harmonics. The additional harmonic eddy losses should be based on the measured 50 Hz eddy losses and the agreed calculations from the design review meeting. Normally, the total losses equal to the sum of the no load losses and the load losses is supplied rather without an additional 10% losses. However, in the case of transformers experiencing service harmonics the additional harmonic eddy losses should be added for the test.	Already in the specification, it is mentioned that 10% addition on sum of the load and no load losses, the basis of the agreed calculations from the design review meetings cannot be standardized.
52.	6.3.1.3.1 Item 4,7,8 6.3.1.3.2 6.3.1.3.3	• The measurement of hot resistance shall commence as soon as possible after switching off. The first reading of the resistance shall be taken before the expiry of 90 s from the instant of switching off and the first ten readings shall be taken at intervals of 15 s apart.	**M/s ABB** We would recommend that the fibre optic probes are measured at: • 30 sec intervals for the first 15 minutes of the temperature rise • 30 min intervals (whenever the oil temperatures are measured) for the duration of temperature test. • 1-minute intervals when the current is returned to rated current.	Firm comment may be acceptable as this can be measured by the data logger and give accurate measurements.

		Thereafter, another ten readings shall be taken at intervals of 30 s apart. • The temperature of the ambient, top oil, the top and bottom radiator header oils shall also be recorded at half - hourly intervals through out the test starting from the instant power supply is switched on to commence the test till it is switched off. • The WTI and OTI readings shall also be recorded at half-hourly intervals right from the instant the power supply is switched on to commence the test till it is switched off. • After power supply is switched off, the readings of OTI and WTI shall be recorded at intervals of 1 min apart for 30 min.	30 second intervals from the time of shutdown The fibre optic probes will give the most accurate measured value (direct measurement) of hotspot temperature at 50 Hz. These should be used as much as possible. They are also the best source of data to determine the winding time constant.	
53.	6.3.1.7	The temperature rise of the oil, windings and current carrying parts in air under both the overloads conditions stipulated in Clauses 6.3.1.3.2 and 6.3.1.3.3 above shall not exceed the values stipulated in Clause 5.1 (14) of this specification. The winding hot - spot temperature under the overload conditions shall not exceed 115^0 C.	**M/s ABB** We believe that the reference to Clause 5.1 (14) should be Clause 5.1 (12). We recommend that a winding hotspot temperature rise limit is added to clause 5.1 for both rated load and overload. It should be clear whether these limits include harmonic current temperature increases or are for 50 Hz load only. For the limit given for winding hotspot, it is recommended to express it as a temperature rise rather than temperature otherwise the ambient temperature needs to be included. We have also suggested some changes to the allowable temperature rise limits given in clause 5.1 based on modern knowledge and more accurate data for winding hotspot calculation, inclusion of the effects of harmonics and the use of fibre optic probes	Already specification mention that for overload condition
54.	6.3.1.9	Determination of the thermal time constant of the WTI: The thermal time constant of the WTI shall be determined for comparison with the thermal time constant of the winding of the transformer with respect to the transformer oil. For this purpose, the indications of the WTI and the OTI shall be	**M/s ABB** We recommend that some reference to the use of fibre optic probe results to determine winding time constants should be included.	The required changes to be made in the exiting para has not been suggested in the comment.

<table>
<tr><td></td><td></td><td>recorded every 1 or 2 min during the first 1 h from the instant the transformer is loaded. From the slope of the curve plotted with the time on the X - axis and the difference between the readings of the WTI and OTI at the particular time on the Y - axis, the thermal time constant of the WTI shall be determined. This value shall not vary appreciably from the thermal time constant of the winding as calculated theoretically and as ascertained from the slope of the cooling curves</td><td></td><td></td></tr>
<tr><td>55.</td><td>6.3.4.2</td><td>Tests prior to short circuit:
(9) Recording of recurrent surge oscillogram (RSO) at the highest, lowest and principal tapping</td><td>M/s Prime Meiden
RSO can be conducted at works before and after the SC test but not at the place (namely Indian Govt Test labs in India who does not have this facility at their end) where SC test will be conducted. Therefore, we recommend to include the RSO under Routine Test.</td><td>The tests prior and after the short circuit test can be conducted at the manufacturer works, the para in the specification shall be modified accordingly.</td></tr>
<tr><td>56.</td><td>6.3.4.3</td><td>The test shall preferably be done by closing the breaker on the secondary side after energizing the primary winding at its rated voltage.</td><td>M/s Prime Meiden
We recommend to change the SC TEST method by closing the Circuit breaker
using PRESET method and the same has been recommended by CPRI Testing Lab</td><td>The para mentioned in the specification is preferably not mandatory. Thus, no change required in the specification.</td></tr>
<tr><td>57.</td><td>6.3.4.4</td><td>The transformer shall be subjected to a total of seven shots in the following sequence:
<table><tr><td>Shot</td><td>Current</td></tr><tr><td>1st</td><td>Asymmetrical and symmetrical currents in M-Phase and T phase respectively</td></tr><tr><td>2nd</td><td>Symmetrical and asymmetrical currents in M-Phase and T phase respectively</td></tr><tr><td>3rd</td><td>Asymmetrical and symmetrical currents in M-Phase and T phase respectively</td></tr><tr><td>4th</td><td>Symmetrical and asymmetrical currents in M-Phase and T phase respectively</td></tr><tr><td>5th</td><td>Asymmetrical and symmetrical currents in M-Phase and T phase respectively</td></tr></table></td><td>M/s Prime Meiden
We as per our manufactured and supplied Transformer in DFCC project, recommend to change the sequence to the following. This has also been recommended by CPRI Test Lab.
<table><tr><td>shot</td><td>Current</td></tr><tr><td>1st</td><td>Symmetrical current in T-Phase respectively at the highest tap.</td></tr><tr><td>2nd</td><td>Asymmetrical current in T-Phase respectively at the highest tap.</td></tr><tr><td>3rd</td><td>Symmetrical current in T-Phase respectively at the principle tap.</td></tr><tr><td>4th</td><td>Asymmetrical current in T-Phase respectively at the principle tap.</td></tr><tr><td>5th</td><td>Symmetrical current in T-Phase respectively at the lowest tap.</td></tr><tr><td>6th</td><td>Asymmetrical current in T-Phase respectively at the lowest tap</td></tr><tr><td>7th</td><td>Symmetrical currents in M-Phase respectively at the highest tap</td></tr><tr><td>8th</td><td>Asymmetrical currents in M-Phase respectively at the highest tap.</td></tr><tr><td>9th</td><td>Symmetrical currents in M-Phase respectively</td></tr></table></td><td>Since in the Indian standard, the sequence has not been defined.

The decision on this may be taken after making communication from the short circuit type testing agency.</td></tr>
</table>

		6th: Symmetrical and asymmetrical currents in M-Phase and T phase respectively 7th: Symmetrical currents in M-Phase and T phase at the lowest tap	at the principle tap. 10th: Asymmetrical currents in M-Phase respectively at the highest tap. 11th: Symmetrical currents in M-Phase respectively at the lowest tap. 12th: Asymmetrical currents in M-Phase respectively at the lowest tap.	
58.	6.3.8.1.3	Mechanical Endurance Test: With the tap-changer in oil, 100 operations shall be done manually and 10,000 operations shall be done with the motor drive unit. An operation shall comprise moving the tap-changer from one tap position to the next higher or lower tap position. All the taps of the tap-changer i.e. maximum position tap to the minimum position tap shall be covered during the test. While testing with the motor drive unit the D.C. voltage for the motor drive unit shall be adjusted to the values indicated below, and the number of operations at each value of voltage shall be as indicated against each. 1. At the minimum DC voltage of 93.5 V DC 2500 operations 2. At the maximum DC voltage of 121 V DC 2500 operations 3. At the rated DC voltage of 110 V DC 5,000 operations.	M/s Toshiba With the tap-changer in oil, 1000 operations shall be done manually. An operation shall comprise moving the tap-changer from one tap position to the next higher or lower tap position. All the taps of the tap- changer i.10% position tap through the 15% tap shall be covered during the test.	In field the tap change is to be operated by the 110V DC Motor, so in type test motor operation is mentioned. This test is for the tap changer design type test, which is not done on the tap changer which is installed in the transformer. Only the already conducted type test report of tap changer is required to be submitted, which should be as per the specification requirements.
59.	6.3.8.1.5	Short Circuit Current Test: The test shall be done in accordance with IEC: 60214 or IS: 8468 with short –circuit currents mentioned in clause no. 3.10.	M/s TOSHIBA The test shall be done in accordance with IEC 60214 with short circuit current of 4kArms each 5sec duration.	The value and duration of the short circuit current shall be mentioned in the specification in line with the IS: 8468.
60.	6.4 Item 10	Dielectric tests comprising: 1) Separate- source voltage withstand test. 2) Induced over voltage withstand test.	**M/s ABB** We recommend that the RSO test should be made a type test. Additionally, if the supplier has suitable lightning impulse design software to demonstrate the developed voltages including waveforms then we suggest that the results of the software outputs could be accepted instead of RSO tests. We note that for the 2x25kV single phase autotransformer, that RSO assessment may not be necessary as there are very few voltages that can be measured. We suggest that the scope of the RSO	The comment for the acceptance of the software outputs instead of RSO test is not accepted. The reason for mentioning the RSO test only in type test is not justified, thus the comment of the firm is not accepted.

			measurements should be added to this clause.	
61.	6.8	The manufacturer may quote separately his charges for short-circuit and temperature rise tests. No charges shall be payable for any other type and routine tests.	**M/s Prime Meiden** We recommend to change the mentioned clause of RDSO as: 'The manufacturer may quote separately his charges and time for short-circuit and temperature-rise tests, keeping in view the timelines of Short-circuit test at testing lab.	The clause shall be removed from the specification as these may be the tender conditions may not require in the specification.
62.	8.0	The offer shall include the training of two personnel of the Indian Railways free of cost at the manufacturer's works in India or abroad and at the maintenance depots/workshops on a Railway system or other public utility where transformers of similar/identical design are in operation. The total duration of training for each personnel shall be 2 weeks of which approximately one week will be at manufacturer's works and one week on a Railway system or other public utility. If the country of manufacturer is not India, the cost of travel to that country and back will be borne by the Indian Railways. Other details shall be settled at the time of finalizing the contract/Purchase Order.	**M/s ABB** We recommend that the scope and type of training required is given in this clause. eg Installation procedures, maintenance procedures, familiarisation with accessories and features etc. **M/s Prime Meiden** We would like to recommend in place of highlighted content as: As the 2x25 kV system is first being adopted now in India, therefore, few limitations shall arise at depots/worskhops or at public utilities alongwoith the limitation of training materials/facilities. Therefore, we would like to request for removal of the and at the maintenance depots/workshops on a Railway system or other public utility where transformers of similar/identical design are in operation.	Firm comment is justified and clause may be modified in the final draft. Already 2X25kV system is in operation in Indian Railways since 20years back, it is not being first adopted at present.
63.	9.2	The transformer shall be dispatched with its core and windings along with the tap-changer assembly in the transformer tank filled with oil and the space above the oil filled with pure dry air or inert gas like nitrogen at a pressure slightly above atmospheric pressure. However, if there are limitations on account of weight, the tank shall be filled with nitrogen under pressure and the oil for the first filling shall be supplied separately in steel drums. In case the tank is filled with inert gas the temperature and pressure at the time of filling shall be marked conspicuously on the transformer.	**M/s Prime Meiden** We recommend to change the mentioned clause of RDSO as: 'However, if there are limitations on account of weight, the tank shall be filled with nitrogen/dry air under pressure and the oil…… steel drums'.	Firm comment may be accepted in view of the present practices being followed by different manufacturers that Transformer is transported with dry air filled.

64.	9.8	The transformer shall be erected and commissioned by the Purchaser. The successful tenderer /manufacturer shall invariably make available at site the services of an engineer of his to ensure, by his continued presence, that the process of erection, testing and commissioning of the transformer is in accordance with established practices. For this purpose prior intimation regarding the dates/period and locations at which the transformers are to be erected and testing / commissioning done shall be given by the Purchaser to the successful tenderer /manufacturer. No charges shall be payable by the purchaser to the successful tenderer /manufacturer for the services of his engineer in this regard	**M/s Prime Meiden** We recommend to add the intimation of requirement of Supervisor (SV) at site at least 2 weeks prior to the site requirements. Further, to avoid idleness of manpower (of Indian Railways and Transformer manufacturer), we shall submit a 'Site Readiness Checklist' alongwith the O&M Manual at the time of Transformer dispatch from Factory for validation by Indian Railways personnel at site/respective office, which shall be returned back to Transformer manufacturer to initiate and process the SV requirement.	The duration of two weeks cannot be mentioned in the specification as it may be as per the site requirements and conditions.
65.	9.9	If any transformer has been received at site in a damaged condition and in the opinion of the Railway's Engineer at site it is required to be repaired at the successful tenderer/manufacturer's works, the transformer shall be taken back to the works promptly and after repair, all necessary tests including the routine tests shall be done on the complete transformer in the presence of and to the satisfaction of the Railway's Engineer prior to returning the transformer to site. Such tests are necessary to ensure that the quality of the workmanship during repairs is satisfactory and shall be done free of cost. Any tests, as decided by the Railway's Engineer at site shall also be conducted on the transformer at site free of cost.	**M/s ABB** We would recommend that transport acceleration measurement using transport impact recorders is added. Additionally, that factory and site SFRA testing is performed to confirm the integrity of the transformer from damage. The allowable accelerations during transport should be required in the offered returnable schedules.	“Transport acceleration measurement” is not described in the comment, also the existing para of the specification is more clear, thus no change is required.
66.	Anne xure2	FOS	**M/s ABB** We recommend that the quantity of fibre optic	Firm comment may be accepted for

			probes is increased to ensure redundancy and correct location for winding hotspot of both windings. We would also recommend that during the design review meeting that the supplier must demonstrate the temperature rise and fluid velocity of every disc to ensure that the winding hotspot location is correctly located and understood.	getting more accurate results. The clause shall be modified.
67.	Annexure4	Force calculations	**M/s ABB** We recommend that these force calculations are replaced with the requirement to perform electromagnetic field plots and design specific dynamic response calculations. Please see more detailed comment against the other clauses.	The suggestion of the firm has not been supported by any national or international document, thus in the specification so it is not feasible to incorporate.
68.	10.1	The manufacturer shall warrant that all equipments shall be free from defects and faults in design, material, workmanship, manufacture and are of the highest grade consistent with the established and generally accepted standards. The equipments are in full conformity with this specification and shall operate properly.	**M/s Prime Meiden** We recommend to delete and shall operate properly. The highlighted content, as we shall submit the Operation and Maintenance manual in hard copy during the Transformer dispatch from factory, which is to be followed by the Indian Railways personnel.	Firm comment is not acceptable, the manufacturer of the Transformer should take responsibility for proper operation of the transformer.
69.	9.9	If any transformer has been received at site in a damaged condition and in the opinion of the Railway's Engineer at site it is required to be repaired at the successful tenderer/ manufacturer's works, the transformer shall be taken back to the works promptly and after repair, all necessary tests including the routine tests shall be done on the complete transformer in the presence of and to the satisfaction of the Railway's Engineer prior to returning the transformer to site. Such tests are necessary to ensure that the quality of the workmanship during repairs is satisfactory and shall be done free of cost. Any tests, as decided by the Railway's	**M/s Prime Meiden** We recommend to delete the “in the opinion of the Railway's Engineer at site “to avoid any discrepancy at later stage, as the requirement is not clear. We recommend to delete the last highlighted content i.e. 'Any tests, as decided by the Railway's Engineer at site shall also be conducted on the transformer at site free of cost.', as the requirement of test at Factory is already stated in the preceding contents	This clause is to ensure that every efforts are made by the manufacturer to reach the job on site in a good condition, any specific test requirement cannot be mentioned in the specification as it may vary as per the situation.

		Engineer at site shall also be conducted on the transformer at site free of cost.		
70.	10.3	**Warranty** The manufacturer's liability in respect of any complaint, defects and/or claims shall not be limited to the furnishing and installation of replacement of parts free of any charge or the repair of defective parts only to the extent that such replacement or repairs are attributable to or arise from faulty workmanship or material or design in the manufacture of the goods, provided that the defects are brought to the notice of the manufacturer within 3(Three) months of their being first discovered during the warranty period of 3(Three) months from the date of expiry of warranty period, or at the option of the Purchaser, to the payment of the value, expenditure and damage as hereafter mentioned	**M/s Prime Meiden** We recommend to change the content of notice to manufacturer 'within 3 months from date of expiry of warranty period' to 'within the warranty period'.	Firm comment is not accepted, it is not expected that the equipment are failed within three months after the warranty period.
71.	10.4	The manufacturer shall, if required, replace or repair the equipment of such portion thereof as is rejected by the Purchaser free of cost at the ultimate destination or at the option of the Purchaser. Manufacturer shall pay to the Purchaser value thereof at the contract price or in the absence of such price at a price decided by the Purchaser and such other expenditure and damages as may arise by reason of the breach of the conditions herein specified.	**M/s Prime Meiden** We recommend to delete "manufacturer shall, if required, replace or repair the equipment of such portion thereof as is rejected by the Purchaser free of cost at the ultimate destination or at the option of the Purchaser. Manufacturer shall pay to the Purchaser value thereof at the contract price or in the absence of such price at a price decided by the Purchaser and such other expenditure and damages as may arise by reason of the breach of the conditions herein specified" as the requirement in RDSO draft specification is not clear.	The clause shall be modified.
72.	10.5	All replacement and repairs that the Purchaser shall call upon the manufacturer to deliver or perform under this warranty shall be delivered and performed by the manufacturer, promptly and satisfactorily and	**M/s Prime Meiden** We recommend to change the clause to: All replacement and repairs that the Purchaser shall call upon manufacturer to deliver or perform under this warranty shall be delivered and performed by the manufacturer, promptly and satisfactorily and in any case within 5(Five)	Firm comment is not accepted, Railway Traction Transformer is used with the public traffic movement, and five months is a very big time for this

		in any case within 2(Two) months of the date of advice to this effect.	months of the date of advice to this effect.	application.
73.	10.8	The decision of the Purchaser in regard to successful tenderer/manufacturer's liability and the amount, if any, payable under this warranty shall be final and conclusive.	**M/s Prime Meiden** We recommend to delete the highlighted content, as the requirement in RDSO draft specification is not clear.	The specification requirements are clear, no change is required
74.	11.2	The manufacturer shall make necessary arrangements for closely monitoring the performance of the transformer through periodical (preferably once in two months during the warranty period) visit to the locations where they have been erected for observations and interactions with the operating and maintenance personnel of Indian Railways. Arrangements shall also be made by the manufacturer for emergency /standby spare parts being kept readily available to meet exigencies warranting replacement so as to keep the transformer in service with least down time.	**M/s Prime Meiden** We shall provide the O&M manual as stated in above recommendations, for necessary steps of operation at site. Operating and maintaining the equipment/s lies completely with the Indian Railways as per maufcaturer's O&M with no liability of Transformer manufacturer for periodic visit. Further, for spare parts, Indian Railways shall provide the additional list of required spare parts incase required and we shall quote for the same with the delivery timeline. However, it shall not be possible to store the spare parts at our works as emergency/standby spare parts.	In the specification preferable duration is mentioned, the duration may be decided by the manufacturer as per their convenience. However, the spares shall be available with the manufactures to keep the break down time minimum.
75.	11.3	The manufacturer shall respond promptly on any call given by Indian Railways for any assistance by way of attending to failures, investigations into the causes of failures including the tests, if any, to be done and such other items with a view to seeing that the transformer serves the purpose for which it is procured. Besides, technical guidance to ensure proper operation and maintenance of the transformer shall be constantly rendered.	**M/s Prime Meiden** We recommend to delete the "Besides, technical guidance to ensure proper operation and maintenance of the transformer shall be constantly rendered" as the requirement in RDSO draft specification is not clear	Technical guidance can be provided by the manufacturer, if required to user. No need to change the clause.
76.	----------	Design of the Transformer	**M/s High Volt (For** 54MVA, 220/2X27kV Scott Transformer Only) For the Scott Connected Transformer, it is suggested to have two separate transformers one having the main and other having the teaser winding, the connection of the Scott to be made at external bushings , M1M2 – 25kV of Main transformer T1T2 - 25kV of Teaser transformer	The suggestion of the firm for the two separate tanks is theoretical, if it is in operation in any of the utility (in India or any other country) same may be communicated. If firm

			N1N2 will brought out from both the transformer on bushing and will be connected externally by jumper. Advantages of this scheme are as below: 1. Losses Losses shown in 54MVA are more because of higher current and flux density which is not in line with RDSO Requirements. The main reason behind low flux & current density in RDSO specification is for the below reason; (a) The Railway system in India is mostly overloaded. This over loading is some time cyclic and sometime abruptly due to failure of Railway and /or grid system. During these period the system must take this overloading without any failure. (b) Transformer failure is causing much more difficulty in Railway system as they create blocking of train ultimately suffering of passenger and goods to repair even replacement take a lot of time hence it must cover over capacity. (c) Energy efficiency is added advantage for their life cycle calculation. 2. Construction of transformer The transformer used in DFC are Scott Connected. The main transformer and Teaser Transformer is housed in one tank. Due to this entire Scott connected transformer size become very large, say about 80 Tone transportation weight, total weight 126 Tone. The size of transformer becomes very large making the transit almost difficult on road. A special permission is required and it cannot reach into some of the interior area of traction Substation. If the Main and Teaser Transformer are manufacture individually the weight of each transformer will become less than half for transportation. Because the weight of each transformer will be 45% of the combined transformer. Reduction in material/weight will bring down the cost. Reduction will be cost effective. Reduction in transportation/handling commissioning at site will reduce substantially.	has manufactured Scott connected transformer with separate main and Teaser enclosure, same may be communicated for the reference and consideration of this office for this design. The Overloading capacity of transformer for 15 minutes and5 minutes is already defined in the specification. The provision of Stand by transformer and feed extension is already available. It is not expected that, the total losses of both transformers will be less than a single transformer. Any firm have should have the manufacturing and testing facilities as per the requirements of the transformer size. Many of the utilities in India are using the three Phase Transformers above, 100MVA, so the transportation reason in the present scenario of resources is not considerable. It is not expected that, the total material requirement of both transformers in comparison to a single transformer will be

			We expect a 40% saving in transportation & commissioning charges. The manufacturing of such large transformer require very large material handling capacity i.e. crane 200MT & other jigs & fixture costing higher machinery cost. The processing of such large transformer require very large Vapour Phase Drying system and prolonged time resulting the processing cost very high. All above points make transformer of single unit with Main & Teaser transformer in one tank result in huge cost escalation. 3. Operation/maintenance Due to separate unit it is easy to do maintain individually & quickly. However on case of failure of one unit, whole transformer become redundant. While if two transformer one installed separately the whole system will work at fail transformer is replaced. Repair will have too much of hassle for removing, transportation & back after repair will cost very heavy. Having both transformer separate only one part is to repair. The same can be repaired easily by having spare of the same capacity.	lesser.
77.	Rating	54MVA, 220/2X27kV Scott Connected Transformer	**M/s High Volt (For** 54MVA, 220/2X27kV Scott Transformer Only) It should be as 54MVA, 220, 132, 100, 100 or 66kVkV /2X27kV	This rating is being used in a section only. For the new sections 60/84/100MVA Scott Connected Transformer is to be used, in this the required kV has already been mentioned, so no change is required.
78.	Annexure-6	Diagram of Principal of AT feeding)	**M/s BHEL** There are only one 54 KV winding each in M-phase and T-phase (ie. total 4 LV terminals taken out), with one terminal of LV winding of each phase connected to OHE and other terminal of LV winding of each phase connected to feeder. Therefore there is no mid point at 25 KV available for earthing as shown in the diagram (as is available in 54 MVA scott transformer with 2 LV windings per phase). The diagram may therefore be reviewed.	This diagram is general diagram representing the principle of 2X25kV System. In the TSS the mid-point is earth through the Autotransformer. No change in the Diagram is required.
79.	General	----------	**M/s ABB** We have made a number of significant	Noted

			recommendations in areas including: • Short circuit force calculation withstand and consideration of frequent short circuit faults. Calculation and control of dynamic winding response during short circuits. • Understanding and limiting of temperature rise particularly for the use of winding hotspot including the effects of harmonics • Scope, Benefits and importance to include a detailed design review meeting • Use of modern "dry type" condenser bushings and solid resin/polymer bushings to further reduce fire risk and improve safety. • Determining transformer quality from and analysing FAT results. We realise that these may be significant considerations whose reasons/benefits cannot easily be described in a few sentences. Therefore, we offer as part of our specification feedback to deliver to Customer Knowledge Training on the above topics The Indian Ministry of Railways.	The design of the Traction transformer is done by the transformer manufacturer, technical specification is a requirement which is verified by the certain tests which are mentioned in the specification The remarks on the comments on the specific clause has already been mentioned at respective clauses.
80.	General		**M/s ABB** Given the frequent and severe short circuit duty of the transformers, we recommend the use of the latest technology and analysis techniques for short circuit withstand. The recommended aspects include: • Calculation of electromagnetic forces using field plots. • Design specific dynamic response of the windings to be determined. • Inclusion of winding offsets to account for manufacturing tolerances and pitch of helical windings. • Use of modern mechanical withstand limits associated with high density, high grade materials • Consideration of free buckling modes of radial failure • Design of inner windings that do not rely on inner supports for radial buckling withstand ("self-supporting" windings). This ensure ongoing short circuit withstand and withstand of free buckling failure. • Reduction of withstand limits to account for the frequency of short circuit. • Use of epoxy bonded continuously transposed cable Detailed assessment of short circuit testing requirements	----do-----
81.	General		**M/s ABB** These transformers are subjected to high levels of harmonics in service. The harmonics significantly increase the winding hotspot temperature being concentrated at the winding ends. However, the harmonics cannot be supplied during factory acceptance testing (FAT). We therefore recommend that a detailed analysis is conducted including how they are managed by	----do-----

			appropriate winding design. This aspect and others should be prescribed for the design review meeting. Further, it is important to understand, simulate by calculation and correct the 50 Hz measured losses and temperature rise from the FAT to the service situation. This is facilitated and made more accurate with the use of fibre optic probes during FAT to have accurate winding hotspot measurements. In at least some transformers we would recommend that service measurements of the fibre optic probes including the harmonics losses should be conducted to validate the simulations and impacts on the WTI readings.	
82.	General		**M/s ABB** For transformers of this type which include harmonics, frequent short circuits, a short circuit type test, nitrogen injection systems & thermo-syphon equipment, fibre optic probes etc, we would recommend a detailed design review meeting. In addition to the criteria described in CIGRE Brochure 529 and IEC 60076 the design review meeting should define broad scope and expectations including: • Short circuit calculations for design specific dynamic forces and control for frequent short circuits. • Effect of harmonics in service (which cannot be supplied at the supplier factory). • Temperature rise details including temperatures and fluid velocity of every disc of the main windings • Assessment of the true winding hotspot gradient both without and with harmonics • Correction of FAT temperature rise results to the values expected with harmonics in service The use and placement and measurement of fibre optic probes.	----do-----
83.	General		Our understanding from the specification that management of fire risk (inclusion of nitrogen injection and fire extinguishing system) is of importance. We would therefore recommend the use of modern technology bushings: • Dry type condenser bushings (resin impregnated paper/synthetic - RIP/RIS) instead of OIP. These dry type bushings tend to act as a plug when they or the transformer suffer an internal failure whereas OIP bushings shatter and expose the transformer internal to oxygen (fire risk) or contamination (porcelain and burnt paper). • Solid resin/polymer bushings rather oil filled porcelain bushings - same benefits as the RIP bushings. In general, we would also recommend polymer sheds for the outdoor side of al bushings instead of porcelain as this removes the safety risk for personnel of shrapnel like pieces of porcelain in the event of failure.	Noted.

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