

Technical Specifications

1. Thread Locker Adhesive:

- 1.1. Adhesive means 'non-metallic substance capable of joining materials by surface bonding (adhesion), and the bond possessing adequate internal strength (cohesion). Thread locker adhesive is a chemical compound in liquid form, it is applied to a surface/substrate in a liquid state to adapt the joint geometry on one or both surfaces, which penetrates in gap of threads of nut & bolts and hardens or cures in absence of oxygen to achieve adhesion and cohesion.

2. **Applicable Codes and Standards:** The latest version of the codes and standard up dated prior to 28 days before latest date of Bid submission shall be applicable for execution of work.

3. Terminology

- a) **Thread Locker Adhesive:** single-component anaerobic adhesives suitable for locking, sealing, and retaining threaded or cylindrical assemblies. The thread locker adhesive remains in the uncured state by oxygen, as in air, and that cures in the absence of oxygen when exposed to metal ions, especially copper or iron.
- b) **HSFG Bolts:** High Friction Grip Bolts.
- c) **Substrate:** A material upon which an adhesive is applied.
- d) **Surface preparation:** Mechanical or Chemical method used to make a substrate more receptive to forming an adhesive bond.
- e) **Curing of Adhesive:** Change in physical properties of an adhesive to develop the strength by chemical reaction, by several factors, including temperature, moisture, the presence of a catalyst or, in the case of thread lockers, a lack of oxygen.
- f) **Handling Time:** Time taken by the compound to set initially. Alternatively. the minimum time required after application of the compound for the part to be handled for consequent assembly operation.
- g) **Adhesion:** Adhesion is an interaction between a substrate and an adhesive where the two meet. Two types of interaction result in good adhesion: one is a molecular interaction (for example chemical bonds, 'Van der Waals' forces), and the other is a mechanical interlocking called 'mechanical keying' in the assembly.
- h) **Cohesion:** Cohesion is an interaction between the molecules of a substance within an adhesive. This is a combination of 'Van der Waals' forces and covalent bond forces in the adhesive molecules. The material properties of an adhesive are defined by the cohesive strength and are independent of the adhesion strength between the adhesive and the substrate.

- i) **Breakaway Torque:** The initial torque required to break the bond, measured at the first movement between the nut and the bolt, when unscrewing an unseated assembly, after curing of thread locker adhesive. The break-away torque is an indicator of thread locker strength alone. In other words, it is the force necessary to rotate nut on bolt, the engaged threads of which are fixed with the cured compound.
- j) **Break loose torque:** The initial torque required to break the bond between a standardized nut and the bolt in a seated assembly. The break-loose torque is more relevant to the clamp load and friction involved in a real-life fastener application. In other words, maximum value of torque observed when clamped or seated fastener is being loosened.
- k) **Locking Torque:** Locking torque in a fastened Joint is a turning or twisting force required to produce a rotation about an axis.
- l) **Prevailing Torque (PT):** The average force (torque) needed to provide continuing movement to the nut after un seating through one full turn, namely, after measuring breakaway torque.
- m) Glass transition temperature T_g : Approximate midpoint of the temperature range over which the glass transition takes place

4. **Packing & Marking:**

- 4.1. **Packing:** Anaerobic adhesives remain liquid (stabilized) in the presence of oxygen. The anaerobic bottles are intentionally filled half-way so the oxygen in the empty space will prevent the thread locker from curing. Additionally, the bottles shall be made from air permeable low-density polyethylene, ensuring the presence of sufficient oxygen to prevent curing.
 - a) The material shall be packed in 5 ml to 250 ml packing;
 - b) The containers should be leakproof with a suitable cap. If desired by the user, the cap may be shaped in the form of nozzle for easy application.
 - c) The containers should be made up of LDPE and preferably coloured to minimize UV radiation entry in the compound; and
 - d) The filled Containers should be packed in wooden crates/ or any other suitable material packing to avoid the damage in transit.
- 4.2. **Marking:** Each container shall be legibly and indelibly marked with the following:
 - a) Product Code Number, batch and lot number and material stock number
 - b) Manufacturers Name.
 - c) Date of Manufacture of product and expiry date
 - d) Complete instructions for application and use
 - e) Storage and caution instructions
 - f) Standard Mark.
- 4.3. The Supplied thread locker adhesive having any air leak or damaged packing, shall be discarded and shall not be used for the work.
- 4.4. The Material during transportation, loading, unloading and storage shall be handled properly to avoid any air leakage or damage to the packing.

5. Properties of Thread Lockers:

5.1. Thread locker adhesives shall provide anti-vibration, anti-theft and anti-corrosion measures.

5.2. **Properties of Thread lockers in Uncured State:** The following properties of thread locker in uncured state influence how the product performs when being applied to nuts and bolts.

- a) **Viscosity:** Viscosity is a measure of resistance to flow at a given shear rate. A wide range of viscosity is available. A low viscosity compound is intended for use in closely fitting joints or for application to the outside of an assembled joint into which the compound is introduced by capillary action. The high locking strength compounds are intended for use on high strength assemblies or short engagement areas or where a permanent or semi-permanent joint is required. —Measure the viscosity of the uncured adhesive in accordance with Test Methods ASTM D 1084 (Method B) or Test Method ASTM D 445.
- b) **Lubricity (K factor):** This property reduces torque tension scatter.
- c) **Ultraviolet Fluorescence:** Thread lockers should contain additives that are fluorescent under UV light. This acts as a quality control or troubleshooting tool to check whether the thread locker product has been applied or not.
- d) **Oil tolerance:** For optimal adhesion, surfaces should be clean and free of contaminants. However, it is not always realistic to have completely clean surfaces. Therefore, the “Thread lockers” should have the property to cure and adhere on lightly oil-contaminated surfaces. Test report/ technical data sheet should cover the compatibility of thread locker with engine oils, corrosion prevention oils and cutting fluids, which are the most common contaminants found on nut and bolt surfaces.

5.3. **Properties of Thread lockers in cured State:** the properties in a cured state relate to the performance of bonded assemblies in their service environments. These properties are as under.

- a) **Break-away torque:** The torque required to break the bond between the nut and the bolt assembly of unseated assembly on which thread locker adhesive is applied and cured, by rotating nut or bolt is known as ‘break-away torque’. The break-away torque for respective thread locker adhesive shall be tested as per ISO 10964.
- b) **Break- Loose torque:** Maximum initial value of the torque observed when a clamped or seated fastener that has been locked using mechanical or chemical means starts rotation/loosening. The Break Loose Torque shall be tested as per ISO 10964.
- c) **Prevailing Torque:** Prevailing torque is the effort required to maintain rotation of a threaded fastener after any locking mechanism has been released. This torque is measured after the break-away or break-loose torque measurement. The prevailing torque value is normally measured at 180 degrees of rotation. The Prevailing Torque shall be tested as per ISO 10964.
- d) **Shear strength of thread lockers:** Shear strength in a thread locker is the shear force required to break the thread locker adhesive bond. High tolerance pin and collar test specimens are used to perform this testing. Detailed information

regarding method of this testing is provided in ISO 10123. While torque testing uses rotational force to evaluate the adhesive strength in a threaded assembly, this test uses compressive force to push an unthreaded pin that is adhesively bonded to the inner diameter of a collar. Due to the high dimensional tolerances of the specimens, this method provides the best estimate of the true shear strength of thread lockers.

- e) **Hot strength:** The average strength of adhesive measured at an elevated temperature are reported as hot strength.
- f) **Heat Aging:** Heat aging is conditioning that exposes a bonded joint to an elevated temperature for a given period of time without exposure to stress. It is then brought back to room temperature, 23°C (73°F), and tested to determine the strength at room temperature. Heat aging test helps to understand the strength retention in applications when the parts might be subjected to extended periods of elevated temperature but brought back to room temperature prior to being subjected to forces.
- g) **Chemical resistance:** A bolted assembly is often exposed to various environmental factors and/or chemicals in its service life. For testing the effect of these factors, the nut and bolt assembly exposed to a chemical or solvent for a given period of time, then removed and strength is tested at room temperature immediately after removal from the chemical.

5.4. The Thread “Locker Adhesive” supplied for execution of work, shall full fill the requirement of Clause 13 of BS-111- R7-2023 as well as following physical & technical properties also:

- a) Specific gravity @ 25°C : 1.1
- b) Viscosity: High: Measured by Brookfield Viscometer -RVT at 25±1°C, Spindle-3, Speed 20rpm: 2000 to 3000 mPa.s(cP)
- c) Lubricity K factor 3/8"x16 Zinc plated steel nuts ≥0.16
- d) Florescence: Positive under UV light
- e) Curing Time: Min. 24 Hrs. - Max. 168Hrs
- f) Glass Transition Temperature: ISO 11359-2 in °C
- g) Coefficient of Thermal Expansion Reciprocal kelvins (K⁻¹): Tested as per ISO 11359-2 / ASTM E 1545: Measured Below tg: 95×10-06, Above tg : 190×10-06
- h) Compressive shear strength at std. atmospheric condition: ≥ 25 Mpa (As per ISO-10123/ ASTM D4562, the Thread locker adhesive applied to steel pin and collar assembly after completion of curing time the specimen tested at 22 °C)
- i) Compressive shear strength With Castrol BP Hysol X Oil applied specimens: ≥ 19.5 Mpa (As per ISO-10123/ ASTM D4562, the Thread locker adhesive applied to steel pin and collar assembly after completion of curing time the specimen immersed in Castrol BP Hysol X Oil. Specimen tested at 22 °C)
- j) Breakaway Torque at temp 23 °C: ≥230Nm
(tested as per ISO 10964, for Unseated: M20 mild steel bolts, (10.9 grade) and nuts assembly after curing of 72 Hrs)
- k) Prevail Torque @ 360° rotation & temp 23 °C: ≥150Nm
(tested as per ISO 10964, for, Unseated: M20 mild steel bolts (10.9 grade) and nuts)
Curing time & Curing speed at normal condition and high temperature & Low temperature both
- l) Break loose Torque / Locking Torque at temp 23 °C: ≥125% to 150% of pre-

torqued value.

Tested at standard atmospheric condition, as per ISO 10964/ASTM D 5363, M20 mild steel bolts (10.9 grade) and nuts, pre-torqued to 400Nm and cured up to 72 Hrs.

- m) Hot Strength tested with in 30sec, after 115min to 125min heating at temp 200°C :
≥ 40% of Maximum strength at 23 °C after completion of Curing time:
tested as per ISO1023/ASTM D4562 using Steel pins and collars, after completion of Curing time)
- n) Heat aging i.e., strength tested at temperature 23°C, after aging at 120°C for 5000hrs ≥ 150% initial strength
Tested as per ISO1023/ASTM D4562, using steel collar pin method, after completion of Curing time
- o) Chemical/Solvent Resistance
- p) Thread locker adhesive applied on M20 Nut and Bolt assembly pre- torqued to 400 Nm, cured for complete curing period of respective adhesive and aged under various conditions and tested @ 23°C. Break Loose Torque as per ISO 10964

SN	Environment Condition	Aging Hours	Aging Temp °C	% Initial strength (min)
1	Hydrochloric acid, 10%	220 Hrs	23°C	≥80%
2	Acetic Acid, 10%	220 Hrs	23°C	≥90%
3	Phosphoric Acid, 10%	220 Hrs	23°C	≥90%
4	Sodium Hydroxide, 20%	220 Hrs	23°C	≥90%
Salt Spray Test as per ASTM B 117				
	Salt Spray Chamber	500 Hrs		>110%

6. Application Method:

6.1. Surface preparation:

- 6.1.1. Correct surface pre-treatment is necessary for optimum bonding. Bond strength is determined to a great extent by the adhesion between the substrate and the adhesive, so the substrate shall be cleaned thoroughly. The more thoroughly the surfaces are cleaned, the stronger the adhesive joint will be. Complete removal of oil, grease, dust and other residual dirt from the bond surface is required for optimum bond strength. Solvents that evaporate without leaving residues are suitable for this. Alkaline or acid-based aqueous cleaning systems such as corrosion inhibitors remain on the cleaned bond surfaces, they may reduce the adhesion of the adhesive.
- 6.1.2. In every case, substrates must be thoroughly rinsed or wiped off. If special degreasing baths are used for larger production runs, it is advisable to preclean very dirty surfaces so the cleaning batch is not contaminated. The surface preparation shall be done by manual cleaning by mechanical means and/ or using chemicals
- 6.1.3. To remove contamination and selection the correct cleaner, may based factors like type of contaminant (inorganic/organic), polarity of contaminant, substrate compatibility, part geometry, health and safety regulations and type of process to be used.

6.1.4. **Aqueous-based cleaners:** Aqueous, or water-based cleaning is mainly used when large parts or large quantities of parts are cleaned in one bath process. For optimal performance, aqueous cleaning is usually done at temperatures of 60°C–80°C (140°F–176°F) with a specified immersion interval. The parts should then be rinsed with demineralized water to prevent mineral deposits, which may affect adhesion.

Aqueous cleaners almost always contain corrosion inhibitors, so testing for compatibility with the adhesive is recommended. Aqueous cleaners are required significant drying time, the added energy required to speed the drying process, flash rust and maintaining the bath solution.

6.1.5. Solvent-based cleaners

Solvent-based cleaning processes usually involve dip baths, closed solvent steam chambers or manual wiping processes (which are most commonly used to clean low volumes of assemblies immediately prior to bonding). Metallic swarf and inorganic components cannot be removed by solvent-based cleaners. However, if oil or grease (such as cutting fluid) is causing the inorganic soils to adhere to the surface, solvent-based cleaners are effective.

6.1.6. Manual cleaning:

- a) Remove all contaminations such as dust, rust, grease, oil, paint or any other chemical from the surface and clear the substrate for application of
- b) For manual cleaning, apply a fast evaporating cleaner from its container (pump spray or aerosol) and wet a white, lint-free cloth. Wipe the cloth in one direction only, not back and forth.
- c) For nuts and bolts, wrap the cloth around the threads and turn the fastener. Clean the part until it no longer discolours the cloth.
- d) For through holes or blind holes, apply cleaner and clear the hole with clean, dry compressed air. It is possible to assist the chemical degreasing process by separating dirt from the surface through mechanical action, for example, by rubbing with a stiff brush.
- e) If the Bolt is coated with paints apply the suitable paint remover and/or any mechanical means such as wire brush, scraper etc.. After removing the paint clean the surface as stated above.
- f) If bolt is rusted in such case remove the rust by mechanical means such as wire brush, scraper etc and/or apply the suitable rust remover, After removing the rust clean the surface as stated above.

6.1.7. **Random selection of Bolts and determining Break Loose Torque Value:** Randomly, select the bolts of different dia fixed to the Bridge Girders to determine the break loose torque before application of thread locker adhesive. Apply the torque to loosen these bolts and note the maximum value of torque required to just rotate/loosen the nut/bolt. This will give break loose torque of un-treated fasteners.

6.1.8. **After** ascertaining the break loose torque the HSFG nut bolt assembly shall be discarded and shall be replaced by new HSFG Bolt, Nut & Washers.

The contractor shall fix the new HSFG Bolt, Nut & Washers and torque them with suitable torque wrench. No extra payment shall be made for opening & fixing of HSFG Bolt assembly.

6.2. Application of Thread locker Adhesive:

6.2.1. The application of thread locker to threaded fasteners is an important consideration for performance. For maximum reliability, the clearance between the engaged nut and bolt should be filled with the adhesive. Depending on the configuration of the assembly,

different techniques are needed.

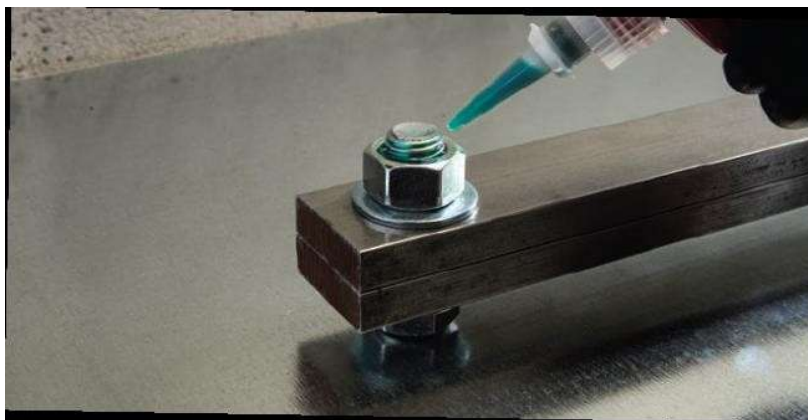
- 6.2.2. **Application of thread locker adhesive in pre-assembly stage (for Standard nuts/bolts and Bolts through holes):** Apply a liquid thread locker onto the bolt and proposed tightened nut engagement area. Any excess thread locker is pushed along with the nut as it is tightened. The volume of thread locker needed depends on the size of the fastener and engagement area. A minimal amount of thread locker squeezing out from the nut and bearing surface interface indicates that a sufficient volume of product has been used to fill the clearance. Therefore, bolt wise actual consumption of thread locker shall be recorded while applying at the site.



Proper application of thread locker on a pre assembly stage.
Placement of thread locker must be closer to the end of the bolt.

- 6.2.3. **Application of thread locker adhesive in post-assembly stage (i.e. in already assembled girder with completed torquing of fasteners):** When a threaded assembly has already been assembled and torqued to the target clamp load, a wicking grade thread locker can be used. This is particularly suitable for locking adjustment and/or set screws or for preventative maintenance on existing equipment. Product should be applied at the nut and bolt junction, as shown in Figure. Avoid touching the bottle tip to the metal. For post assembly purpose wicking grade thread locker shall be used.

Bolt wise actual consumption of thread locker shall be recorded while applying at the site.



Proper post assembly application; wicking thread locker.

- 6.2.4. **Random selection of Bolts and determining Break Loose Torque Value after**

application and Curing of thread locker adhesives: After application and curing of suitable thread locker adhesives, randomly, select the bolts of different dia to determine the break loose torque. Apply the torque to loosen these bolts and note the maximum value of torque required to just rotate/loosen the nut/bolt. This will give break loose torque of un-treated fasteners.

- 6.2.5. After ascertaining the break loose torque of HSFG bolt assembly treated with thread locker, the said HSFG nut bolt assembly shall be discarded and shall be replaced by new HSFG Bolt, Nut & Washers.
- 6.2.6. The contractor shall fix the new HSFG Bolt, Nut & Washers and torque them with suitable torque wrench. No extra payment shall be made for opening & fixing of HSFG Bolt assembly. These new bolts shall be treated with thread locker adhesive and for which payment shall be admissible to the contractor under relevant provision of bid document.
- 6.2.7. As per Clause 13(a) of BS-111 (Rev-7), Anti-theft and Anti-sabotage measures: Where it is apprehended that theft/sabotage might take place, the tack welding shall not be resorted to as anti theft measure as it may have adverse impact on metallurgical properties of HSFG bolting assembly due to careless or improper tack welding and will adversely affect the functioning of bolting assemblies. Hence, tack welding in HSFG bolts shall not be resorted to as anti theft measure for whatsoever reason. Instead, suitable bonding agent (like Loctite, Kent, Devcon or any other functionally similar product) to seize or lock the bolt in position may be applied to the threads projecting beyond the nut. Any bonding agent must increase the torque required for opening of bolt by minimum 200 Nm (RDSO report no. C-226 may be referred to), accordingly the Break loose torque or opening torque of HSFG bolt assembly treated with, thread locker adhesive must have value at least 200N-m more than the break-loose torque/ opening torque value of HSFG Bolt assembly not treated with thread locker adhesive.
- 6.2.8. In case if particular sample bolt assembly do not confirm the of Cluse 13(a) of BS-111-R7-2023, additional 3 nos treated bolts of same size shall be selected and tested for break loose/ opening torque. Out of 03, if results of 02 Bolts confirms requirement of Cluse 13(a) of BS-111-R7-2023, then it will be considered as the all-treated bolts of particular size full fills the requirement of Clause 13(a) of BS-111-R7-2023. If in revised sample more than 02 test results do not confirms any of the bolts of additional sample fails to confirm the requirement in such Contractor shall rectify the work of particular bolt size of particular girder and no extra payment shall be made for such rectification.
- 6.3. **Dispensing Thread Locker Adhesive:** There are a variety of options available for dispensing thread locker adhesives, from fully manual to fully automatic and everything in between. Selection of a dispensing method, depends on following factors:
- Chemistry type
 - Process requirements

- Package size

Together, these three factors determine which equipment can be used to dispense an adhesive, and equipment is only chosen after these factors are thoroughly evaluated.

Manner of application, for example dispensing of beads, dots and films, is determined by the viscosity and the flow behavior of the adhesive. The fluorescent property of adhesive is used to check "whether thread locker adhesive has been dispensed/applied or not."

- 6.4. **Curing Process:** The thread locker adhesive go through a curing reaction and transition from a liquid to a solid polymer. The curing action is direct function of the development of adhesive strength.

Adhesive cure speeds vary greatly from hours to days and will typically be stated on a technical data sheet.

Cure time means the time required for full or close to full strength. Cure speed may be affected by different factors, such as ambient conditions, catalysts, substrates, gap and the use of activators.

The cure development profile will also be displayed on technical data sheets, represented in a graph of strength build over time. The cure speed may be impacted by factors such as substrate and ambient conditions.

- 6.5. **Bonding process:** In a bonding process, the cycle time and the number of pieces to be bonded are primary factors. Cure speed, fixture time, handling strength and clamping time may also affect this process.

- 6.6. **Fixture time:** There are several laboratory tests to measure fixture time. One such test defines it as the time needed for a standardized bond to reach a shear strength of 0.1 N/mm² (14.5 psi). Fixture time should not be confused with handling time, which is specified for each application individually.

- 6.7. **Full cure time:** It is the time interval required for an adhesive to reach its full strength. A fully cured adhesive has achieved its intended mechanical and physical properties, like resistance to external forces and resistance to chemicals and thermal aging. The final strength will be indicated in technical data sheets through various test methods.

- 6.8. **Cure temperature:** Temperature is one of the most important variables when considering adhesive cure characteristics, as the cure speed will be inversely affected by a rise or fall in temperature. A general rule is: for every 10° C (18° F) that the temperature increases, the stated time required for the adhesive to cure will be halved. Conversely, a reduction in temperature of 10°C (18°F) will double the stated cure time. Depending on the chemistry, a point will be reached where curing will nearly stop. Higher curing temperatures cause faster cross-linking of adhesive molecules and a higher grade of cross-linking. In general, lower curing temperatures lead to a slower cure speed and a lower cross-linking.

7. **Root causes of failure :** There are three common root causes of unexpected failure:

- 7.1. **Incomplete coverage of the bond area:** Incomplete coverage of the bond area can be due to insufficient application of thread locker adhesive, or due to adhesive being pushed

out of the adhesive bond joint, either by air displacement or pressure applied to the joint. The thread locker adhesive contain fluorescent additives that allow detection under UV light. This can be an important feature to aid in detecting the presence or traces of an adhesive.

7.2. Insufficient adhesion to the substrate: The root cause of the insufficient adhesion to the substrate can be due to incompatibility with the substrate or due to contamination. Proper surface preparation/cleaning helps in removing contamination there by increasing adhesion with sub- strate.

7.3. Incomplete curing of adhesive: It is possible that the adhesive has not achieved its full cohesive strength due to incomplete curing. In order to achieve the expected strength within an assembly, it is important to make sure that the adhesive is completely cured. There are a many reasons why an adhesive would not achieve full cure, some of them are as under;

- a) Adhesives in contact with some materials can experience interactions that will limit the curing reaction and result in insufficient cure. eg, when an anaerobic material is in contact with nitrites (which is commonly find in a corrosion inhibitor found in lubricants, cleaners and protection fluids), the curing reaction can be inhibited. Select suitable type of inhibitor, lubricants, cleaners or protection fluids. After use of the inhibitor, lubricants, cleaners or protection fluids avoid this rinse the surface with demineralised water, clean the surface properly.
- b) Ambient temperatures can also influence the curing rate of an adhesive. At cold temperatures, most curing reactions will typically slow down, which will result in a slower strength build up than observed at higher temperatures. The cure speed will be inversely affected by a rise or fall in temperature. If unavoidable, the application work should not be carried out in very cold weather condition.
- c) Part-to-part variations in the dimensions of the bond gap between substrates can also impact the cure speed of the adhesive. Selection of suitable adhesive may minimize the problem.