Recommended Practice for Care and Use of Fiberglass Tubulars

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Content

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Recommended Practice for Care and Use of Fiberglass Tubulars

1 Scope

The purpose of this Recommended Practice is to provide information on packing, transporting, handling, storing and installing fiberglass tubulars in oilfield usage.

Trouble-free service and maximum safety should result if this Recommended Practice is followed. Fiberglass tubulars differ in properties from metallic tubular goods and different installation techniques are required.

NOTE No provision of this Recommended Practice shall be cause for rejection of fiberglass tubulars provided the ends are in accordance with the requirements of the applicable product specification.

NOTE The recommendations listed in this document are applicable to normal situations. Exceptional conditions may require different practices. It is not intended that these practices conflict with any regulatory code.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies, except that new editions may be used on issue and shall become mandatory upon the effective date specified by the publisher or 12 months from the date of the revision (where no effective date is specified).

API Specification 5B, *A Specification for Threading, Gauging and Thread Inspection of Casing, Tubing and Line Pipe Threads*

API Recommended Practice 5B1, *Gauging and Inspection of Casing, Tubing and Line Pipe Threads*

API Specification 15LR, *A Specification for Low Pressure Fiberglass Line Pipe*

API Specification 15HR, *A Specification for High Pressure Fiberglass Line Pipe*

ASTM D1599, *A Test Method for Short-Time, Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings*

ASTM D2105[1], *A Test Method for Longitudinal Tensile Properties of Reinforced Thermosetting Resin Pipe and Tube*

ASTM D2584, *A Test Method for Ignition Loss of Cured Reinforced Resins*

ASTM D3839, *A Standard Practice for Underground Installation of Flexible Reinforced Thermosetting Resin Pipe and Reinforced Plastic Mortar Pipe*

AWWA C-950[2], *AWWA Standard for Fiberglass Pressure Pipe*

[1] ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

3 Terms, Definitions, Abbreviations, and Symbols

3.1 Terms and Definitions

3.1.1
breakout
The process of unscrewing threaded connections.

3.1.2
casing
A tubular which is cemented to the wellbore and used to maintain wellbore integrity

3.1.3
casing and tubing application
An application where the tubular is installed vertically inside a well.

3.1.4
doubles
Two joined lengths of tubulars

3.1.5
derrick
The structure used to support the drill string of a drilling rig.

3.1.6
fiberglass
A generic term for glass-fiber-reinforced thermosetting resins.

3.1.7
fishing
The process of removing debris from the wellbore.

3.1.8
line pipe application
An application where the tubular is installed horizontally.

3.1.9
makeup
The process of tightening threaded connections.

3.1.10
manufacturer
Refers to the firm, company, or corporation responsible for making and marking the product to warrant that this product conforms to the specification.

3.1.11
pulling
The process of breaking out threaded connections and taking out tubulars from the well.

3.1.12
running
The process of installing tubulars in the well.

[2] American Water Works Association, 6666 W. Quincy Avenue, Denver, Colorado 80235, www.awwa.org.

3.1.13
triples
Three joined lengths of tubulars

3.1.14
tubing
A tubular which is installed inside the casing string and used to transport oil and gas from the well to the outer surface or from the outer surface to the well.

3.1.15
tubular
A pipe which is used for either a casing and tubing or a line pipe application.

3.1.16
visual inspection
Examination of parts and equipment for visible defects in material and workmanship.

4 Units of Measure

A decimal/inch system is the standard for the dimensions shown in this document. Nominal sizes will continue to be shown as fractions. For the purposes of this recommended practice, the fractions and their decimal equivalents are equal and interchangeable. Metric conversions are described in Appendix F.

5 Packing

Fiberglass tubulars shall be packed so that the body and connections are protected during shipping, unloading, storing, and handling. The manufacturer shall apply external and internal protectors of such design, material and mechanical strength to protect the threads, and/or ends, of the tubular and coupling from damage under normal handling and transportation. External protectors shall cover as minimum the effective length of the external thread, or bonding area. Internal protectors may cover the first 2 to 3 inches of the thread length of the internal thread, and/or bonding surface. Protectors shall exclude foreign matter such as dirt from the threads and from the interior of the tubular. The protectors shall contain no compounds capable of damaging the threads or promoting adherence of the protectors to the threads or bonding surfaces. Refer to the appropriate product specification.

Tubulars should be bundled in crate frames with stripping between each layer to prevent damage to the tubulars, as well as to keep them from shifting. Stripping material should not be placed on the transition or upset areas of the tubulars. For nominal 30-foot lengths, a minimum of four (4) stripping material supports are recommended. Stripping material should be wood and free of protruding nails. Stripping should be placed as near as possible to the end of the tubular and still maintain vertical alignment. Tubulars should be secured with wooden blocks at both ends of spacing strips.

Tubulars should be packed in alternating manner (pin end of one tubular next to box end of the adjacent tubular) to prevent the ends from touching each others and chafing during transportation. Alternatively, tubulars can be packed in alternating manner per layer (pin ends in one layer and box ends in the next layer) where adjoining tubulars in the layer can be staggered an amount approximately the length of the coupling or the box upset.

For land freight, stripping under the bottom layer should be no more than six (6) feet apart, oriented perpendicular to the tubular body and aligned vertically.

For sea freight, a strong wooden base should be made under the bottom layer and the crated tubular bundle should be put inside a container.

6 Transportation, Handling and Storage

6.1 General

Fiberglass tubulars in general, and threads in particular are made with precision and require careful handling. Whether new or used they should always be handled with thread protectors in place.

6.2 Transportation

The following precautions should be taken for land freights to assure that product doesn't get damaged:

a) Trucks that haul tubulars should be the flatbed type and not pole trailers. Bed length of the trailer should be sufficient so that no overhang occurs.

b) Load crated tubular bundles onto the truck slowly and with extreme care to avoid chafing.

c) Suitable tie-downs, such as woven cloth straps, should be used to secure the load. Caution should be used to prevent damaging the tubulars when securing the load. The manufacturer shall locate the tie-downs such that bending of the tubulars is minimized.

For shipments other than by land, packing, loading and protection procedures shall be agreed upon between the purchaser and the manufacturer.

6.3 Handling

The following precautions shall be observed in handling fiberglass tubulars:

a) Prior to unloading, make sure that the protectors are tightly in place. Inspect the body for delaminations (bruises), crazing, indentations, contaminations, embedments, or tears. Upon request, the manufacturer shall furnish descriptive criteria pertaining to visual inspection.

b) Avoid rough handling which might damage the tubulars body or threads. When tubular bundles are being loaded or unloaded, each bundle should be handled individually. Never unload fiberglass tubulars by breaking the crate frame, pulling out the side stakes or sideboards, and allowing the tubulars to roll off the trailer. Do not use hooks for lifting because the ends of the tubular can be damaged. Chains or steel cables shall not be used directly on tubulars while unloading. Woven cloth, nylon, or canvas hoisting slings with spreader bars are acceptable for unloading.

c) If a forklift is used, the forklift arms shall be rubber padded to avoid direct contact between steel and fiberglass tubulars. Additionally, the forklift arms should be spread wide enough to avoid exceeding the maximum allowed deflection of tubulars defined by the manufacturer.

d) All fiberglass tubulars, whether new or used should always be handled with thread protectors in place. Tubulars should always be kept on wooden strips free of rocks, sand, or dirt. Do not keep tubulars directly on ground or metals racks. If tubulars are dragged in sand or dirt, the threads should be cleaned, inspected and serviced again as outlined in 6.1.9.

e) Do not remove thread protector from the pin end of tubulars until ready to make-up.

NOTE Caution should be exercised that fiberglass tubulars are not unduly flexed during any handling operation. Undue flexing occurs when the bend radius is smaller than the manufacturer's recommended minimum bend radius.

6.4 Storage

The following precautions are recommended for storage of fiberglass tubulars:

a) Tubulars should be kept bundled in the crate frame until they need to be used.

b) When tubulars are taken out of the crate, do not pile them directly on the ground, rails, steel or concrete floors. Racks normally used for steel pipe and tubulars are not suitable for fiberglass tubulars.

c) The use of stripping under the bottom layer and between each layer is recommended to prevent damage to the tubulars, as well as to keep them from shifting. For nominal 30-foot lengths, a minimum of four (4) stripping material supports are recommended between each layer. Stripping material should not be placed on the transition or upset areas of the tubular. Stripping material should be no more than six (6) feet apart under the bottom layer, oriented perpendicular to the tubular body and aligned vertically, of uniform thickness within each layer. Stripping material should be wood and free of protruding nails. Stripping should be placed as near to the end of the product as possible and still maintain vertical alignment.

d) Stagger adjoining lengths of tubulars in the tiers an amount approximating the length of the coupling or the box upset.

e) Block tubulars by nailing wooden blocks at both ends of spacing strips.

f) Tubulars should not be stacked higher than 1.5 metres for safety, ease of inspections, loading and unloading.

g) Tubular bundles should be stored separately accordingly to their class and diameter.

7 Inspection Before Use

The following should be considered before using any tubular:

a) Inspection criteria for fiberglass tubulars differs from the criteria used for steel tubulars. It is suggested that in preparation for visual examination of fiberglass tubulars, the individual user familiarize himself with the both inspection practices defined by the manufacturer and summarized in Appendix E, along with the definition of defects contained in Table E.1.

b) Immediately before use, remove the thread protectors from both ends and carefully inspect the threads. Those found to be damaged within the engaged length should be assessed with respect to the allowable limits specified in Table E.1. Tubulars found with damaged threads exceeding the allowable limits or affecting the integrity, as confirmed by the manufacturer, should be replaced and sent for thread reforming. Repairing damaged thread is not advised.

8 Make-up of Threaded Joint

In assembling threaded joint, it is extremely important that the threads are clean and dry before applying thread compound. Any sand or other foreign material in the threads will cut them and may result in improper make-up or failure of the threads. The following procedure is recommended:

a) Remove thread protector from the pin end of tubulars immediately before makeup.

b) Brush dirty threads with a clean industrial moustache brush. This is extremely important on tubular that has been in prior service. Wire brush shall not be used because it may damage the threads.

c) Wash dirty threads and then dry them with clean tissues or rags. Any liquid remaining in the root of the threads will prevent good thread lubrication.

CAUTION The manufacturer's directions, precautions, and Material Safety Data Sheets for cleaning fluids should be read and observed. Observe appropriate regulations relative to disposal of used cleaning fluids.

d) Cover pin and box threads with thread compound.

e) Apply sufficient thread compound, as recommended by the manufacturer, to coat the thread surface on both the pin and the box. Thread compound have a significant impact on the performance of the connection, especially under combined loading conditions. It is used to lubricate the thread surfaces to facilitate joint make-up and break out without galling and to seal voids between mating thread surfaces and effectively prevent leakage. Use a thread compound recommended by the manufacturer. The brush, or utensil, used in applying thread compound should be kept free of foreign matter and the compound should never be thinned. Contaminated thread compound shall not be used. The material safety data sheet for thread compound should be read and observed. Store and dispose of containers and unused compound in accordance with appropriate regulations.

NOTE PTFE tape is not required to seal API 8-round threads. Its use may increase in leak tightness when connections are made up without torque control. Use only as specified by the manufacturer.

f) Fiberglass threads may be damaged by over-tightening. Start the threads by hand, making sure the thread is straight. Make-up hand-tight, then tighten with a strap wrench or manufacturers supplied wrench. Use powered wrenches with caution. Apply torque slowly to make-up the connection to the recommended torque or standoff values established by the manufacturer. Make-up practices should be in accordance with the manufacturer's recommendations.

NOTE The torque values for make-up of fiberglass pipe are significantly lower than torque values required for steel tubulars.

NOTE Proprietary connections should be joined according to the manufacturer recommendations.

9 Tubing and Casing Application

9.1 Preparation Before Running

a) Before running in the hole, tubular interiors should be drifted, in accordance with API Specification 5CT, throughout its entire length. Tubulars that don't pass the drift test should be laid aside.

b) It is recommended that the user select the joint of tubular to be installed at the top of the string before starting to run in the hole. Because of the permissible tolerance on the outside diameter straight behind the tubular upset, difficulties may occur when wrap-around seal-type hangers are used with fiberglass tubulars manufactured on the high side of the tolerance.

c) Elevators should be in good repair, and should be visually inspected and have links of equal length. Latch fittings should be complete.

d) Standard elevators are recommended for all threaded and coupled installations. For integral joint installation, slip type elevators, without a setting ring, are recommended because integral joint tubulars will wedge in standard elevators as weight increases beyond 5,000 lb. Below this weight, standard elevators may also be used. Where standard elevator inner diameter is bigger than the tubular upset outer diameter, a split ring shall be mounted into the elevator to reduce the elevator inner diameter to the outer diameter of tubular upset. Alternatively, a shoulder that fits the inner diameter of the elevator should be built-up on the integral box upset.

e) Spider slips should be examined before using to ensure that they are working together and that they will not crush the tubular.

f) The length of each tubular shall be measured prior to running. A steel tape calibrated in decimal feet to the nearest 0.01 ft should be used. The measurement should be made from the outermost face of the coupling or box to the position on the externally threaded end where the coupling stops after make-up. The total of the measured individual lengths of tubulars will represent the unloaded length of the tubing or casing string. The actual length of the tubing string under tension in the hole can be obtained by consulting the manufacturer.

g) Place clean protectors on the pin end of the tubular so that the threads will not be damaged while rolling tubulars onto the rack and pulling into the derrick. Thread protectors may be cleaned and reused for this operation as long as they are not damaged.

h) The tubular should be lifted into the derrick carefully, tailing the pin end, to prevent damage to the tubular, coupling, and protector.

9.2 Stabbing, Making Up, and Lowering

a) Center rig over well bore prior to running. Check alignment periodically on deep wells.

b) Clean the threads and apply thread compound as described in section 8.

c) Stab vertically, with the assistance of personnel on the stabbing board. Care should be exercised to prevent misalignment or tilting after stabbing. If either occurs, the tubular should be lifted and the pin and box threads cleaned to remove any fragments and inspected in accordance with Table E.1. If damage is observed but is within the limits specified in Table E.1, thread compound can be reapplied and stabbing continued, otherwise, the tubular should be replaced. Intermediate supports should be placed in the derrick to limit bowing of the tubulars.

d) Make-up joints after stabbing as described in section 8.

e) During make-up, powered tongs should be used with extreme caution to avoid damaging the tubular upset. Scratches on the tubular upset surface left by tongs are common and doesn't affect the integrity unless they are as deep as reaching to the tubular body outer diameter. The manufacturer shall be consulted when such deep marks are observed. The use of pipe wrenches is recommended for sizes smaller than 5.5".

f) Spiders, slips, and elevators should be cleaned frequently and slip inserts should be kept sharp.

g) Finding bottom should be accomplished with extreme caution. Do not set tubulars down heavily.

h) When lowering tubulars into the well bore, care should be exercised to avoid abrupt stops which can result in dynamic loadings. Stop tubular motion prior to setting the slips. Exercise caution when running couplings through slips and blowout preventor.

9.3 Care of Tubulars in Hole

Drill pipe run inside fiberglass tubulars shall be equipped with drill pipe protectors. Drill pipe protectors shall not be steel. Steel protectors may cause marring in the tubular.

9.4 Fiberglass-to-Steel Connections

When making threaded fiberglass-to-steel connections in tubing and casing applications, use a steel cross-over coupling with threads matching the fiberglass threads on one end and standard steel threads

on the other end. The preferred steel-to-fiberglass connection is fiberglass pin in a steel coupling (box). It is not recommended to cut threads from the fiberglass pin or to connect a steel pin to a fiberglass coupling.

CAUTION Fiberglass pipe threads are typically long form. Short form steel threads are often used in line pipe installations. When connecting the long form pin into the short form coupling (box), use a steel cross-over coupling.

9.5 Pressure Testing

In case of pressure testing the casing or tubing string, the test pressure shall not exceed the design pressure of the weakest casing, tubing or connection in the string.

The use of bridge plug with slips having steel teeth is not recommended. Bridge plug with diamond-type knurled slips should be used.

In case of work-over or well intervention, the test pressure shall not exceed the original test pressure used during drilling of the well.

9.6 Pulling Tubing

The following should be considered when pulling the tubing out of the hole:

a) During disengagement from bottom hole tools and equipment, extreme caution is required to assure that tubing is free to exit the hole. A calibrated weight indicator should be used. Fluid levels in the tubing and casing annulus should be equalized by filling or swabbing. The live load of the tubing in the fluid should be determined so the rig operator is sure he has tubing weight during the first lift. Never exceed the manufacturer's rated tensile loading to get loose from bottom hole tools.

b) If tubing is stuck, try lowering the tubing, to one half the string live load, then lift again (with rotation if required) up to manufacturer's maximum recommended tensile rating. Several cycles may be required if a lot of sludge or sediment is accumulated at the bottom of the hole. If tubing remains stuck at the bottom, it is more economical to shoot or mill off the tubing at the joint above the bottom hole connection than to pull the string apart. More of the string will be saved and there will likely be fewer fishing trips required.

c) In case of coupler connection type, the back-up chain tong should be engaged on lower side of the coupler of the bottom pipe, approximately 1 inch from the edge of coupler, while the power tong should be engaged in the pin upset zone of the upper pipe to be unscrewed. In case of integral connection type, the back-up chain tong should be engaged on the upset but as far as possible from the power tong. In both cases, the chain tong shall be ensured to be well aligned and not engaged at an angle. Additionally, the power tong jaws should be well aligned to the pipe body. It is recommended to set the power tong at low gear to let the pressure set gradually for few minutes. Hammering directly on the coupling, or integral box, to break out the joint is a potentially damaging practice. If tapping is required, use a rubber-based hammer or wooden slat (2 x 4) between the 2lb conventional hammer and fiberglass. Tap lightly at the middle of the engaged thread to be broken out, and completely around the threaded joint. Do not tap near the end, or on opposite sides only. Tapping should be done while applying a constant break out torque. The operators shall always check the pipe alignment and level it out while the power tong is unscrewing the pipe.

d) Care should be exercised to disengage all of the threads before lifting the tubing out of the coupling or integral box. Do not jump tubing out of the coupling / integral box or continue to rotate after last thread is disengaged.

e) After the break-out, a thorough visual inspection on pipe, coupler / integral box and threads shall be conducted to evaluate the condition of each component. Tubing and threads should be inspected per

Table E.1 and defective joints shall be segregated. Tubulars found with damaged threads exceeding the allowable limits or affecting the integrity, as confirmed by the manufacturer, should be replaced and sent for thread reforming. Damaged threads shall not be repaired.

f) All threads should be cleaned from dirt and clean thread protectors should be mounted to protect threads from dirt or damage before tubing is set back.

g) Tubing set back in the derrick should be set on a firm wooden platform and should be properly supported to prevent undue bending. Tubing 3-in. O.D., and larger, can be pulled in stands approximately 60 feet long (doubles). Stands of tubing 2-7/8-in. O.D. or smaller, should have intermediate supports. Stands longer than 60 ft (i.e. triples) are not recommended.

h) Prior to leaving the location, always firmly tie a setback of tubing in place.

i) If tubing is being retrieved because of a failure, it is imperative to future prevention of such failures that a thorough study be made. Every attempt should be made to retrieve the failed portion in the “as failed” condition. When analysis reveals some facet of product quality to be involved in the failure, the results of the study should be reported to the API office in Washington, DC.

9.7 Re-running Tubing

The following should be considered when re-running the tubing:

a) Make sure threads are undamaged, clean, and well coated with thread compound before re-running.

b) Distribute joint and tubing wear by reversing the string each time the tubing is pulled. That is, the first joint removed from the well should be the first joint to be run into the well. When pulling doubles, alternate the breakout joint to distribute wear on the connections.

9.8 Completion Practices

It is important to consider the completion practices to avoid misuse and damage of casing and tubing tubulars:

a) Fiberglass tubing string should always be left in tension.

b) Prior to running fiberglass tubing in steel casing, the casing should be scraped and circulated to remove scale or other restrictions in the ID that may impair downhole operations. If the casing size is not definitely known, a drift or calliper should be run.

c) Fiberglass-to-steel connections should be in the form of fiberglass pin to steel crossover coupling. Refer to section 9.4 for more details.

d) Fiberglass tubing installed in open hole completions should be equipped with centralizers, jet plugs, or tubing anchors without rubber elements to prevent free swinging and unscrewing.

e) Permanent, or drillable packers used with fiberglass tubing set with a latch in assembly are preferred. Do not use compression set packers.

f) Tension packers should be set with a weight indicator to obtain proper tension. Packers should be equipped with soft rubber (50 to 65 Durometer A) elements.

g) Fiberglass tubing used in rod pumping installations shall be equipped with tubing anchors to minimize breathing and buckling.

h) Sucker rods installed in fiberglass tubing should be plastic coated. Nylon or hard rubber rod guides should be used to minimize tubing wear.

i) Couplings (box ends) on fiberglass tubing are larger than equivalent steel sizes, therefore, care should be taken to provide adequate clearance, e.g. for cables in submersible pump installations.

9.9 Fishing

Standard oilfield fishing tools (spears, overshots, etc.) can be utilized when fishing is necessary. Care should be taken to fit the tools to the outside diameter and inside diameter of the tubulars. Fiberglass tubular dimensions do not match API dimensions for steel tubulars.

9.10 Milling and Drilling

A standard three cone rock is proven to be a reliable means to drill up fiberglass tubulars. Drilling rates should be governed to produce cuttings small enough to pass through surface piping restrictions (i.e., valves and elbows).

10 Line Pipe Application

10.1 Ditch Preparation

For ditch preparation, the following should be considered:

a) The ditch should have vertical sides and be made sufficiently deep so that a protective bedding layer of sand or compacted fine grain soils can be used. The bedding of the trench should be as uniform and continuous as possible. Unevenness, which will cause nonuniform bearing on the pipe, shall be levelled. Care should be taken to minimize damage resulting from rocks, and other materials, which might fall into the ditch. Refer to AWWA Standard C-950, or ASTM D3839, for additional information on ditch preparation.

b) Horizontal and vertical changes which should require sharper bends than recommended by the manufacturer shall be made with appropriate fittings and the ditch excavated accordingly.

c) When installing fiberglass pipe in a conduit, necessary precautions to prevent damage should be taken. Precautions include the use of saddles, or rigid centralizers, to centre the pipe in the conduit. Trench soil at the conduit end shall be compacted. Pipe should be protected from rough sharp edges at the end of the conduit.

d) Thrust blocks may be needed in some situations where the line changes direction, reduces, dead ends or where excessive expansion variations are anticipated. Follow the manufacturers recommendations in such cases. Refer to AWWA M45 for additional information.

e) When multiple lines are laid in a single ditch, the manufacturer's recommendations on lateral spacing and ditch width should be followed.

10.2 Assembly

10.2.1 General

The method of assembly varies somewhat according to the joining system being used. The following provides guidelines for each of the API standard joint types:

Six-inch and larger line pipe is usually assembled in the ditch. Smaller diameter pipe is normally assembled on the surface and lowered into the ditch Do not exceed the minimum bending radius of the pipe, defined by the manufacture, as it is lowered into the ditch.

Protect the joints during all handling operations. Joints to be adhesively bonded should be protected against exposure to ultraviolet rays during handling operations.

10.2.2 Adhesive Bonded Joints

All adhesive bonding should be performed following a written bonding procedure that has been qualified by test for the application. Personnel doing the bonding should be trained, and qualified by test, to perform the bonding operations. Qualified written procedures, and training assistance, should be available from the manufacturer.

Appendix A provides guidelines for preparation of a written fiberglass pipe bonding procedure.

Appendix B provides guidelines for preparation of a written procedure for qualification of bonding personnel.

Appendix C is a sample bonded-joint inspection sheet.

Exposure of the surfaces to be bonded to ultraviolet rays, even for relatively short periods of time, can significantly reduce joint strength unless the joint is sanded and retapered immediately before bonding. Bells should be protected from exposure until just before the bonding is to take place. Surfaces to be bonded shall be sanded immediately prior to the bonding.

In bonding matched taper bell and spigot joints, product from different manufacturers should not be interchanged. The objective is to obtain a thin uniform bondline. Excessive adhesive will result in a loss of joint strength.

CAUTION Some components used in the bonding operations may cause skin irritation or burns. Inhaling the vapors should be avoided. The manufacturer's precautions and Material Safety Data Sheets should be read and followed closely. Store and dispose of the container and spent materials in accordance with applicable regulations.

10.2.3 Fiberglass-to-Steel Connections

When making fiberglass-to-steel connections in line pipe applications, connect a steel flange with a fiberglass flange of the same drilling class.

10.3 Pressure Testing

Pressure testing is recommended and required to ensure the line will withstand the maximum operating pressures. Lines in the ditch shall be covered sufficiently to minimize pipe movement. The connections and fittings should be left uncovered for inspection during the testing period. The line may also be pressure tested with covered connections and fittings if agreed between concerned parties.

Pressure testing should be performed using a recording device to monitor/record line pressure as a function of time. A minimum test duration of 4 hours at 1.25 x the maximum system design pressure is recommended when the connections and fittings are uncovered. The maximum field pressure test at the lowest elevation in the piping system should not exceed 1.25 x the pressure rating. During the test hold period, the pipe/connections should be visually examined for evidence of leakage, distortion, or other evidence of damage. When the connections and fittings are covered, the test duration may be extended to 8 hours. Extending the test to more than 8 hours at a pressure higher than the design pressure shall be avoided to eliminate excess line expansion, contraction and movement, due to ambient temperature

change cycles, that were not taken into consideration in the design. In case it is necessary to extend the test beyond 8 hours, the maximum test duration can be 24 hours at the design pressure.

CAUTION Failure of products under pressure can be hazardous to personnel and equipment.

Testing a system for leaks should be done in segments as small as practical. Gases, such as air, should never be used for pressure testing. When water is used, all air should be removed from the lines before the test is started. The water should enter the line at a low point and means provided for bleeding air at high points. Any entrapped air will be compressed during testing and give erroneous results. A successful procedure for accomplishing complete air removal during fill is to force a pig ahead of the water, displacing air while filling the line. Pressure in fiberglass line pipe may not remain constant for certain periods of time where variations in ambient temperature occur. Follow the manufacturer's recommended practices when pressure testing.

NOTE Because of environmental considerations, the use of fresh water for hydrotesting may be desirable.

Air with a maximum pressure of 5 psi may be used for locating leaks. All connections and fittings should be covered with a soap solution to test for leaks after reaching the test pressure. Leaks found by air test can be quickly repaired since water does not have to be removed from the line or pumped from the ditch. Gas lines should be leak tested. Air and odorizer type leak detectors can be used to improve the test.

If pressure testing is conducted on a complete system rather than on individual segments, the test pressure should be governed by the segment having the lowest rating. Water tests should always be at pressures established by agreement between the installation contractor and the purchaser provided they do not exceed manufacturer's recommendation. Applicable governmental regulations shall be considered.

10.4 Backfilling

Backfilling should be done as soon as possible after testing to protect the pipe from damage, i.e. that which could be caused by falling boulders, side wall cave in, flooding of the open ditch, and frozen backfill material. Refer to AWWA Standard C-950, or ASTM D3839, for additional information.

When starting the backfill, care should be taken to place sufficient backfill material beneath the pipe to fill all voids between the pipe and the bottom of the ditch. The pipe should be covered with a fine-grained material, such as sand or loose soil, in accordance with the manufacturer recommendations. Larger-grained fill can be used as the cover is increased.

Special care should be taken for pipe buried with more than three feet of cover to ensure that the pipe is firmly supported by surrounding fill. This support enables the pipe to resist the overburden load of the fill material and in shallower depths, minimizes possible movement of the line which could cause abrasion to the pipe wall.

10.5 Surface Lines

Follow the recommendations given under Sections 4, 5, 7 and 8. Anchor and guide the pipe to prevent movement which could cause abrasion or subject the pipe to excessive loading. Support spans for overhead pipe should follow the manufacturer's recommendations. See AWWA C-950 for additional information.

The use of thrust blocks should be considered. Follow the manufacturer's recommendations. See AWWA M45 for additional information.

11 Causes of Problems in Fiberglass Tubulars

The most common causes of problems in fiberglass tubulars are as follows:

a) Improper selection for strength and design life.

b) Insufficient inspection at the mill or in the field.

c) Careless loading, unloading, and cartage.

d) Damaged threads resulting from protectors loosening and falling off or improper stabbing.

e) Lack of care in handling and storage.

f) Worn-out or improper handling equipment and tools.

g) Improper procedures in running, lifting and pulling tubing.

h) Compression loads or alternating tension or compression loads.

i) Rod cutting and sucker rod breakage.

j) Excessive expansion and contraction due to temperature and pressure fluctuations.

k) Dropping a string, even a short distance.

l) Exceeding internal or external pressure ratings.

m) Erosion from entrained abrasives.

n) Leaky joints under an internal or external pressure are a common problem and may be due to:

- Improper thread compound and/or application.
- Dirty threads, or threads contaminated with foreign material.
- Under-or over-torqueing.
- Galled threads.
- Damaged couplings.
- Exceeding axial tensile strength.
- Worn-out threads.

12 Repair

12.1 Tubing and Casing Application

Tubular with damage in the body should not be repaired in a tubing and casing application, it should be discarded. Tubular with surface damages or shallow scratches in the upset area due to the action of the tong doesn't need to be discarded or repaired because this won't affect the integrity of the tubular. In case of deep dents in the upset, where the dent reaches to the tubular body outer diameter, consult with the manufacturer for the usability or repairability of the tubular.

Repair of leaking connections should be attempted by breaking out the connection, cleaning, and examining the threads. If the threads are acceptable as per Table E.1, thread compound should be applied and the connection made-up and pressure tested. If the connection fails the pressure test, the tubular should be sent for thread reforming and another tubular can be used. If the threads are not acceptable as per Table E.1, they may be reformed in accordance with manufacturers recommendations. The acceptability of reformed threads should always be confirmed by gaging and inspection, in accordance with the API Specification 5B.

12.2 Line Pipe Application

Leaking bonded joints can be repaired by overwrapping or by cutting the joint out of the line and replacing it. The use of a written procedure is recommended. See Appendix D for repair procedure guidelines.

Leaking tubular body can be repaired using saddles or by cutting the leaking section out of the line and replacing it. Alternatively, tubular body leak may be repaired by other proven means if agreed between concerned parties. Manufacturer's written recommendations and procedures should be followed closely in all types of repair.

Leaking threaded connections can be repaired by breaking the connection and reassembling or cutting the connection and replacing it with flanges, or overwrapping. Repair by breaking and reassembling the joint requires cutting the pipe at one side of the joint, breaking the connection, cleaning the threads, reapplying thread compound and reassembling if there was no any damage in the threads. After making up the connection, the line can be connected using fiberglass flanges. Repair by replacing the connection requires cutting the connection out of the line and replacing it with a flanged connection. Alternatively, leaking threaded connections may be repaired by other proven means if agreed between concerned parties. See Appendix D for repair procedure guidelines.

13 Operating Conditions and Considerations

Changes in operating conditions will affect the design life. If the material conveyed is changed from the original service in terms of increased pressure, temperature, or fluid velocity, or change in chemistry, consult the manufacturer's design literature. It is recommended that the manufacturer's design literature for the product used be incorporated and maintained in the well or job file, at the time of installation, for future reference.

For cleaning of strings, i.e., acidizing, hot oiling or other technique, refer to the manufacturer's recommended practice.

The ultraviolet (UV) component of sunlight will degrade the resins used in the production of fiberglass tubulars (during storage).

i) Tubular body. On the body, the degradation due to ultraviolet light exposure is insufficient to affect product integrity, mechanical properties or service life. Ultraviolet light effects are only limited to surface discoloration. Fiber bloom or fazing may occur if the pipe is exposed to

sunlight for more than 3 years. As this effect is only limited to the outer 0.1 to 0.25 mm of the pipe surface, the mechanical integrity of the pipe system is not affected in any way. Pipe will operate at 100% of its rating with no effect on its physical properties. However, if material items are expected to be stored for more than 3 months, it is recommended to cover the material with Tarpaulin sheets, tent fabric, or equivalent in order to avoid surface discoloration and to provide adequate protection against UV radiations or any weathering conditions.

ii) Threaded connections. Significant damage can result due to prolonged exposure. Damage to threaded areas is indicated by whitened and/or powdery surfaces. Consult the manufacturer before installation of tubulars with ultraviolet thread degradation. Fiberglass tubulars should always be stored with thread protectors in place to avoid degradation.

iii) Bonding surfaces. Significant damage, including loss of bond strength, can result due to prolonged exposure of the bonding surface to ultraviolet light. Damage is indicated by whitened and/or powdery surfaces. Consult the manufacturer before assembling pipe with ultraviolet bond surface degradation. Fiberglass pipe should always be stored with protectors in place to avoid degradation.

Annex A
(informative)

Guidelines for Preparation of a Written Adhesive Bonding Procedure

A.1 Scope

The scope of applicability of the procedure should be stated in terms of pipe site, pressure class, application and piping products.

A.2 References

Reference specifications and standards should be cited.

A.3 Bonding Procedure

The procedure specific requirements are cited. These should include consideration of the following:

A.3.1 Environment

The environmental conditions under which the bonding is permitted to take place should be clearly stated. Usual provisions include:

a) Pipe surface temperature permissible during bonding: A range of 60° to 105°F is often specified with heating or cooling provisions included. Surface temperature should also be at least 37.5°F above dew point.

b) Humidity/moisture limits during bonding should be stated. Bond is not recommended on wetted surfaces.

c) Cleanliness levels. Blowing sand and dust usually require some form of protection during bonding as sand/dust in bond joints is detrimental.

A.3.2 Stringing and Blocking

A description of how the pipe is to be strung and blocked (supported) for assembly.

a) A description of stringing instructions. Generally, where the pipe is to be strung and handled.

b) A description of how the pipe is to be blocked. Normally given in general terms with some minimum height above ground surface required.

A.3.3 Surface Preparation

A description of how the pipe is to be strung and blocked (supported) for assembly.

a) Joint protection. Usual requirement is for end caps/protectors to remain in place until just prior to cleaning/bonding.

b) Joint examination. The joint is normally visually checked for cleanliness/damage and UV degradation. UV degradation is detected by sanding and looking for color change. Refinishing by sanding and/or

retapering is often required if UV degradation is detected or if the joint has been exposed for a limited period of time (often specified as 0.5 to 1.0 hours).

c) Tapering instructions should be provided. Reference should be made to specific tools, sandpapers and grits if necessary. Cleaning is always required after sanding or retapering. After tapering, the match up/fit of the joint should be verified. When assembled dry, without adhesive mixture, there should be no looseness.

A.3.4 Joint Cleaning

A detailed description of the joint cleaning procedure, including the materials to be used.

a) Joint cleaner and wiping materials should be specified in detail. Materials are not normally reused.

b) Cleanliness level. The procedure should require all oil, grease, mud and fingerprints to be removed. Once cleaned the joint should not be touched.

CAUTION Solvents are normally volatiles and may build up pressure in containers. A general understanding of the health and safety conditions as stated on the Material Safety Data Sheets is generally required. Storage, transport, use, and disposal of excess materials and containers should be considered.

A.3.5 Adhesives

Detailed instructions for mixing of the adhesives are required.

a) Mixing. Complete mixing instructions should be provided. The instructions should consider the effects of temperature, splitting a kit and determination that mixing is complete. Normal requirements are for adhesive to be in the 60°to 80°F range at time of mixing, no splitting of adhesive kits, and uniform color/consistency.
b) Shelf life. Information relative to the working life of the mixed adhesive is required. The working life is normally specified in terms of time at a specified ambient temperature. Shelf life varies directly with temperature. Instructions often include suggestions for keeping the mix cool, such as, wrapping with wetted rags, or storing in the bottom portion of a cardboard box lined with wetted rags/paper towels.

CAUTION The hardener contained in the adhesive kits might burn the skin. Inhaling the vapors should be avoided. The manufacturers precautions, and Material Safety Data Sheets should be read and observed. Store and dispose of the container, mixing tools, and unused materials in accordance with appropriate regulations.

A.3.6 Joint Assembly

Detailed instructions should be provided for the application of the adhesive and alignment/mating of the joints. This portion of the procedure will depend on the type of joints being bonded and should consider bonding to flanges and fittings.

a) Alignment. Joints shall be axially aligned. Visually detectable misalignment is normally unacceptable.

b) Warming. Bonding surfaces should be heated or cooled to bring to the appropriate bonding temperature. Bonding surfaces should never be touched by fingers or tools after cleaning.

c) Adhesive application. Specific instructions relative to application of the mixed adhesive is required. Instructions normally require brush application of a thin uniform coat (3 to 10 mils) on both surfaces.

Excess adhesive may interfere with obtaining a locked position on tapered joints. Apply adhesive to the bell first to reduce potential for contamination.

d) Alignment and locking of the joint. Instruction on how the bell and spigot are to be engaged. The instructions will vary depending on the type of joint being used. For a tapered bell and spigot joint, the instructions will normally include the use of rubber mallets on small diameter pipe (< 8 in.) and hydraulic come-alongs on larger diameter pipe (> 8 in.). If a hydraulic come-along is used, the pressure required to obtain lock-up is specified along with a maximum pressure loss if the joint is vibrated or tapped with the mallet (to indicate proper lock-up).

A.3.7 Heat-assisted Curing

Requirements for, and acceptable methods of, assisting the joint cure through addition of external heat should be considered.

a) The requirement. A statement is needed to define when heat assistance is required.
b) The method. A statement describing the method to be used to provide the external heat is required. Specific equipment identification is normally provided.

A.4 Examination/Documentation

Each bonded joint should be visually examined and documented if required. A suggested inspection sheet is provided as Appendix C.

A.5 Procedure/Personnel Qualification

Written procedures, and bonding personnel, should be qualified prior to field use. Appendix B provides an outline for personnel qualification.

Annex B
(informative)

Guidelines for Preparation of a Written Pipe Bonder Qualification Procedures

B.1 Scope

The applicability of the qualification tests should be stated in terms of pipe size, pressure class, and joints.

B.2 References

Applicable reference practices, standards, and commercial literature should be clearly identified.

B.3 Instruction

All personnel on installation crews should be provided with instruction on the bonding procedure and joints to be bonded.

B.3.1 Instruction Requirements

Instruction requirements should be stated in terms of who is to instruct and what information is to be covered.

B.3.2 Examination

Pipe bonders are required to pass a written examination prior to proceeding with qualification.

B.3.3 Qualification Test Bond

Each bonder to be qualified should be required to bond a sample connection using the written procedure, and have passed the written examination.

a) Qualification sample. The specimen on which qualification testing is to be performed should be identified in terms of size, pressure rating and joint type. Normally, the bonder works with his crew, and the largest pipe covered by the procedure is bonded.

b) Grading of sample joint. The qualifying agency representative will observe the fabrication of the bonded joint and grade the bonder on his knowledge and application of the procedure.

B.4 Sample Evaluation

The method of testing the sample should be clearly defined. Normally, a short-term pressure-to-failure test in accordance with ASTM D1599 is specified. Loading should be in both the axial and circumferential directions. Acceptance criteria should be specified.

B.5 Qualification

Only persons who pass the written examination, who demonstrate a practical knowledge of the procedure and method and whose test sample passes the criteria of B.4 should be qualified to bond in accordance with the written procedure.

Annex C
(informative)

Sample Joint Inspection Checklist

Inspector: _____ Joint Number: _____
Bonder I.D.: _____ Date and Time: _____

1. Environmental
   Ambient Temperature: _____°F
   Moisture Conditions: _____
   Wind Conditions (Sand/Dust): _____
2. Ground Clearance (16" minimum): _____inches
3. Are end protectors in place? (30 minutes maximum between removal and joint makeup.)
   Spigot: Yes No
   Bell: Yes No

Comments:
_____
_____

4. Ultraviolet Degradation Check:
   Did spigot show degradation? Yes No
   Did bell show degradation? Yes No
   Action Taken:
   Spigot retapered (witness and verify taper) _____(Initial)
   Bell sanded (witness and check bell) _____(Initial)
   Pipe replaced (mark pipe with paint) _____(Initial)

Comments:
_____
_____

5. Joint Cleaning:
   Inspected surface for oil, dirt, etc. Yes No
   Insured clean towels from kits are used. Yes No
6. Adhesive Mixing:
   Adhesive Temperature: _____°F
   Was all hardener used? Yes No
   Was adhesive thoroughly mixed? Yes No
7. Visual inspection of joint alignment. Done Not Done
8. Bonding surface temperature (70° to 120°F). _____°F
9. Was adhesive applied correctly? Yes No
10. Hydraulic come-along. Delta P (1st Blow) ____psi
    Final Pressure ____psi
    Are hydraulic cylinders bottomed out? Yes No
11. Heat Collars:
    Time on: _____
    Time off: _____
    Temperature: _____°F

Annex D
(informative)

Guidelines for Preparation of a Written Repair Procedure

D.1 Scope

The scope of applicability of the procedure should be stated in terms of pipe size, pressure class, application, and piping products. The scope should also describe acceptable repair methods.

The following provide some examples of commonly used repair methods. It is not an endorsement of these techniques for all applications. The manufacturer should determine what is appropriate for application.

D.2 References

Reference specifications and standards, including applicable procedures, should be cited.

D.3 Pipe Saddle Repair

D.3.1 The patch. A length of good pipe is cut and slit longitudinally to remove a segment to form a saddle patch. The size of the segment to be removed (often 120° of circumference) and length of the patch should be specified. The size of the damage to be repaired using this method should also be specified (for 2-in. and larger pipe, a maximum damaged sur-face area with a 2.0-in. diameter is often specified).

D.3.2 Preparation. The patch and damaged pipe area are sanded to remove all gloss in preparation for bonding. The length of the area to be sanded, and sandpaper, including grit, should be specified. At a minimum of 1 inch past each end of the patch, 40 and smaller grit sandpaper is often specified.

D.3.3 Cleaning. The sanding areas require thorough cleaning to remove all foreign material, oils, greases and fingerprints. The cleaning agent (solvent) and wiping materials are normally specified.

D.3.4 Bonding. A heavy coating of mixed adhesive is applied to both surfaces and the patch is snapped into place. During curing the patch is held in place with a hose clamp at each end of the patch. The adhesive is normally specified along with mixing and curing requirements and when (or if) the clamps should be removed. See Appendix A for sample mixing instructions.

D.4 Sleeve Coupling Repair

For damaged areas greater than that permitted to be repaired by saddle patches, a sleeve coupling repair is often used.

D.4.1 The damaged area of the pipe is cut out using an appropriate tool. Care is required to ensure that the entire damage is removed. A maximum damage area is normally specified, often in the 2- to 4-inch range. A hacksaw with a 22 to 26 (teeth per inch) blade is often used.

D.4.2 Preparation. The cut ends of the pipe shall be pre-pared for bonding by tapering and/or sanding. The type of preparation, tools, and the sanding materials required are normally specified.

D.4.3 Cleaning. The sanding areas require thorough cleaning to remove all foreign material, oils, greases, and fingerprints. The cleaning agent (solvent) and wiping materials are normally specified.

D.4.4 Bonding. The procedure should specify the adhesive and mixing instructions. See Appendix A.

D.4.5 A coupling, with appropriate joints at each end, is inserted and bonded in place in the gap. The acceptable joint type, method of preparation for the cut pipe ends, and bonding procedure are normally required to be specified. See Appendix A.

D.5 Pipe Section Replacement and Repair

For damages which are not suitable to be repaired by saddle patches, a sleeve coupling repair is often used.

D.5.1 The damaged area of the pipe is cut out using an appropriate tool. Care is required to ensure that the entire damage is removed. A maximum damage area is normally specified.

D.5.2 Preparation. The cut ends of the pipe shall be prepared for bonding by tapering, or sanding, or as required. The type of preparation, tools, and sanding materials required should be specified.

D.5.3 Cleanliness level. The procedure should require all oil, grease, mud, and fingerprints to be removed. Once cleaned, the joint should not be touched.

D.5.4 Couplings, and a replacement pipe section with appropriate joints at each end, are inserted and bonded in place in the gap. The acceptable joint type, method of preparation of the cut pipe ends, method of establishing the replacement pipe length, and bonding procedure are normally required to be specified. See Appendix A.

D.6 Leaking Joint Repair—Overwrap Procedure

Leaking bonded or threaded joints can be repaired by the method of D.5, or by overwrapping with glass fabric and resin following the manufacturer's recommended procedures.

CAUTION Manufacturer's overwrap procedures should, at a minimum, include information relative to the design of the overwrap procedures for overwrapping, qualification of the overwrap procedure, and adequate proof that new pipe performance ratings are maintained when the overwrap procedure is followed.

D.6.1 Preparation. The leaking joint should be uncovered (excavated) and prepared for overwrapping. The procedure should describe the amount of space required for the overwrapping.

D.6.2 Collar (Bell) Preparation—Beveling. The collar or bell should be beveled by grinding or sanding to form a smooth sloped transition to the pipe body. The equipment and sandpaper to be used, including the grit range, should be specified.

D.6.3 Cleaning. The sanded areas require thorough cleaning to remove all foreign material, oils, greases, and fingerprints. The cleaning agent (solvent) and wiping materials are normally specified. See Appendix A.

D.6.4 Overwrapping. The procedure should specify the adhesive and mixing instructions and the glass fabric to be used. The procedure should include specific instruction on how to overlap the fabric and the number of layers that are required. See Appendix A.

Annex E
(informative)

Tubular Manufacturer's Inspection Techniques and Criteria

E.1 Introduction

The following paragraphs describe inspection techniques used by manufacturers of fiberglass tubulars. This information is provided for guidance. Table E.1 provides a definition of various defects and acceptance criteria useful in visual evaluation of new fiberglass tubulars.

E.2 Mill Test Methods

The following test methods are likely to be required by the API fiberglass tubular specification when it becomes effective.

E.2.1 Mill Tests Performed on Each Joint of Tubular

a) Hydrostatic mill test. Each length of tubular receives a combined tension (150% maximum standard rating) and internal pressure (150% of allowable internal pressure) test for 2 minutes.

b) Visual inspection. Each joint is inspected in accordance with the criteria of Table E.1.

c) Wall thickness. The wall thickness is measured by mechanical or magnetic caliper at least 6 in. from upsets at approximately 90° increments on tube body. The measured values should not be less than the manufacturer's published minimum value.

E.2.2 Mill Tests Performed Once per Lot (5000 Feet or Portion Thereof)

a) Short-time axial failure. A test specimen consisting of a connection with a minimum of five diameters of tubular on either side is tested in accordance with ASTM D2105, except the failure is to be induced within 60 to 70 seconds of loading.

b) Short-time pressure failure. A specimen, as in E.2.3, is tested to failure in accordance with with ASTM D1599 at ambient temperature. Failure should not be less than 85% of manufacturer's published value.

c) Glass content. The weight of glass per unit of length of tubular body is determined in accordance with ASTM D2584. The weight determined should be within 5% of manufacturer's published specification.

E.2.3 Mill Test for Degree of Cure

Demonstration of degree of cure through use of glass transition temperature monitoring. Monitoring should be accomplished with a differential scanning calorimeter once each winding shift.

E.2.4 Mill Thread Gaging

Manufacturers typically gage threads in accordance with API RP 5B1 at the following frequency:

a) Machined threads. Every 25th joint should be gaged (both pin and box threads).

b) Molded threads. First article from each impression mandrel and every 100th part from the mandrel should be gaged.

Table E.1—Recommended Visual Standards

Tube Body and Coupling		
Burn	Thermal decomposition evidenced by distortion or discoloration of the surface.	20% area—lightly blemished, 5% area—distortion or discoloration of the surface. Moderate burn of outer resin layer structural roving.
Chip	Small piece broken from edge or surface.	Permitted if laminate has not been fractured.
Crazing	Fine cracks at or under the surface as seen by the unaided eye.	None permitted.
Cut Roving	Broken or cut outer rovings due to scraping, scuffing, or manufacturing process.	Maximum 3 per pipe with 1 in.2 maximum size such that the wall thickness is not reduced below minimum.
Dry Spot	Broken or cut outer rovings due to scraping, scuffing, or manufacturing process.	None permitted.
Fracture	Rupture of laminate without complete penetration. Visible as lighter colored area of interlaminar separation.	None permitted.
Pits (Pinholes)	Small craters in the surface.	Maximum 1/16" deep, no limit on number.
Resin Drip	Resin protrusion.	Maximum 1/8" high, no limit on number.
Restriction	Any restriction: paste, epoxy or wax, lump, foreign matter in I.D. of pipe.	None permitted.
Scratch	Shallow mark caused by improper handling.	No limit on number if reinforcement is not exposed; if reinforcement is exposed, see Cut Roving.
Inclusions	Foreign matter wound into laminate.	None permitted.
Threads		
Air Bubbles	Small bubbles at crest of threads.	Maximum size 1/8", one permitted. Maximum size 1/16", 10 permitted.
Broken Thread	Light patch at the root of the thread.	Maximum size 1/8" in any direction and one allowed per pin.
Chips	Areas where over 10% of thread height is removed.	Maximum 3/8" long in one thread per connection, none permitted in Lc area.
Cracks	In direction of thread axis.	None permitted.
Flat Thread	Area where top of thread is broken or ground off.	Maximum 3/8" long in one thread per connection not to exceed 10% of the thread height, none permitted in Lc area.
Squareness	Angle perpendicular to pipe axis.	Maximum 1/16" variation in end.
Finish	Finish cut end.	No sharp edges, no exposed loose fiber, no protrusions, no impact areas.

Annex F
(normative)

Metric Conversion

U.S. Customary units are in all cases preferential and are the standard in this document.

Length

1 in. = 25.4 mm

Pressure

1 pound per square inch (psi) = 0.06894757 Bar

NOTE 1 Bar = 100 kilopascals (kPa)

Strength or Stress

1 pound per square inch (psi) = 0.006894757 Megapascals (MPa)

Impact Energy

1 foot-pound (ft-lb) = 1.3558181 Joules (J)

Torque

1 foot-pound (ft-lb) = 1.3558181 newton-meters (N-m)

Temperature

The following formula was used to convert degrees Fahrenheit (°F) to degrees Celsius (°C):

°C = 5/9 (°F–32)

Mass

1 pound (lb) = 0.4535924 kilograms (kg)