Recommended Practice for Care and Use of Casing and Tubing

API RECOMMENDED PRACTICE 5C1
EIGHTEENTH EDITION, MAY 1999

REAFFIRMED, MAY 2015

AMERICAN PETROLEUM INSTITUTE

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Upstream Segment

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FOREWORD

The bar motations identify parts of this standard that have been changed from the previous API edition.

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Recommended Practice for Care and Use of Casing and Tubing

1 Scope

Note: No provision of this recommended practice shall be cause for rejection of casing or tubing provided the threads are in accordance with the requirements of the latest edition of API Standard 5B.

1.1 The statements on corrosion of casing and tubing as given herein were developed with the cooperation of the Technical Practices Committee on Corrosion of Oil and Gas Well Equipment, NACE International (formerly the National Association of Corrosion Engineers).

1.2 It is suggested that the selection of a thread compound for casing and tubing be given careful consideration by the user, bearing in mind that a satisfactory compound should possess certain properties, the major of which are (a) to lubricate the thread surfaces to facilitate joint makeup and breakout without galling, and (b) to seal voids between the mating thread surfaces and effectively prevent leakage. Compounds that have given outstanding service for casing and tubing under both laboratory and field conditions are described in the latest edition of API Bulletin 5A2.

Note: Thread compounds described in the latest edition of API Bulletin 5A2 should not be used on rotary shouldered connections.

1.3 Some generalized suggestions on prevention of damage to casing and tubing by corrosive fluids are given in 4.8.16 and 5.5.15. It is not, however, within the scope of this recommended practice to provide detailed suggestions for corrosion control under specific conditions. Many variables may be involved in a specific corrosion problem and interrelated in such a complex fashion as to require detailed attention to the specific problem. For more complete technical information on specific corrosion problems, the user should consult the official publication of NACE International, *Corrosion*, or contact: Chairman, Technical Practices Committee on Corrosion of Oil and Gas Well Equipment, T-1, NACE Int'l, 1440 South Creek Drive, P.O. Box 218340, Houston, Texas 77218-8340.

2 References

2.1 GENERAL

This recommended practice includes by reference, either in total or in part, the most recent editions of the following standards:

API

Bul 5A2	*Bulletin on Thread Compounds for Casing, Tubing, and Line Pipe*
Bul 5C2	*Bulletin on Performance Properties of Casing, Tubing, and Drill Pipe*
Bul 5C3	*Bulletin on Formulas and Calculations for Casing, Tubing, Drill Pipe, and Line Pipe Properties*
RP 7G	*Recommended Practice for Drill Stem Design and Operating Limits*
Spec 5B	*Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads*
Spec 5CT	*Specification for Casing and Tubing*

AWS[1]

Spec A5.1	*Covered Carbon Steel Arc Welding Electrodes*

2.2 REQUIREMENTS

Requirements of other standards included by reference in this recommended practice are essential to the safety and interchangeability of the equipment produced.

2.3 EQUIVALENT STANDARDS

Other nationally or internationally recognized standards shall be submitted to and approved by API for inclusion in this recommended practice prior to their use as equivalent standards.

3 Definitions

3.1 shall: is used to indicate that a provision is mandatory.

3.2 should: is used to indicate that a provision is not mandatory, but recommended as good practice.

3.3 may: is used to indicate that a provision is optional.

4 Running and Pulling Casing

4.1 PREPARATION AND INSPECTION BEFORE RUNNING

4.1.1 New casing is delivered free of injurious defects as defined in API Specification 5CT and within the practical limits of the inspection procedures therein prescribed. Some users have found that, for a limited number of critical well applications, these procedures do not result in casing sufficiently free of defects to meet their needs for such critical applications. Various nondestructive inspection services have been employed by users to ensure that the desired quality of

[1]American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135.

casing is being run. In view of this practice, it is suggested that the individual user:

a. Familiarize himself with inspection practices specified in the standards and employed by the respective mills, and with the definition of "injurious defect" contained in the standards.

b. Thoroughly evaluate any nondestructive inspection to be used by him on API tubular goods to assure himself that the inspection does in fact correctly locate and differentiate injurious defects from other variables that can be and frequently are sources of misleading "defect" signals with such inspection methods.

4.1.2 All casing, whether new, used, or reconditioned, should always be handled with thread protectors in place. Casing should be handled at all times on racks or on wooden or metal surfaces free of rocks, sand, or dirt other than normal drilling mud. When lengths of casing are inadvertently dragged in the dirt, the threads should be recleaned and serviced again as outlined in 4.1.7.

4.1.3 Slip elevators are recommended for long strings. Both spider and elevator slips should be clean and sharp and should fit properly. Slips should be extra long for heavy casing strings. The spider must be level.

Note: Slip and tong marks are injurious. Every possible effort should be made to keep such damage at a minimum by using proper up-to-date equipment.

4.1.4 If collar-pull elevators are used, the bearing surface should be carefully inspected for (a) uneven wear that may produce a side lift on the coupling with danger of jumping it off, and (b) uniform distribution of the load when applied over the bearing face of the coupling.

4.1.5 Spider and elevator slips should be examined and watched to see that all lower together. If they lower unevenly, there is danger of denting the pipe or badly slip-cutting it.

4.1.6 Care shall be exercised, particularly when running long casing strings, to ensure that the slip bushing or bowl is in good condition. Tongs may be sized to produce 1.5 percent of the calculated pullout strength (API Bulletin 5C3) with units changed to ft-lb (N • m) (150 percent of the guideline torque found in Table 1). Tongs should be examined for wear on hinge pins and hinge surfaces. The backup line attachment to the backup post should be corrected, if necessary, to be level with the tong in the backup position so as to avoid uneven load distribution on the gripping surfaces of the casing. The length of the backup line should be such as to cause minimum bending stresses on the casing and to allow full stroke movement of the makeup tong.

4.1.7 The following precautions should be taken in the preparation of casing threads for makeup in the casing strings:

a. Immediately before running, remove thread protectors from both field and coupling ends and clean the threads thoroughly, repeating as additional rows become uncovered.

b. Carefully inspect the threads. Those found damaged, even slightly, should be laid aside unless satisfactory means are available for correcting thread damage.

c. The length of each piece of casing shall be measured prior to running. A steel tape calibrated in decimal feet (millimeters) to the nearest 0.01 feet (millimeters) 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 or the box stops when the joint is made up power tight. On round-thread joints, this position is to the plane of the vanish point on the pipe; on buttress-thread casing, this position is to the base of the triangle stamp on the pipe; and on extreme line casing, this position is to the shoulder on the externally threaded end. The total of the individual lengths so measured will represent the unloaded length of the casing string. The actual length under tension in the hole can be obtained by consulting graphs that are prepared for this purpose and are available in most pipe handbooks.

d. Check each coupling for makeup. If the standoff is abnormally great, check the coupling for tightness. Tighten any loose couplings after thoroughly cleaning the threads and applying fresh compound over entire thread surfaces, and before pulling the pipe into the derrick.

e. Before stabbing, liberally apply thread compound to the entire internally and externally threaded areas. It is recommended that a thread compound that meets the performance objectives of API Bulletin 5A2 be used; however, in special cases where severe conditions are encountered, it is recommended that high-pressure silicone thread compounds as specified in API Bulletin 5A2 be used.

f. Place a clean thread protector on the field end of the pipe so that the thread will not be damaged while rolling pipe on the rack and pulling into the derrick. Several thread protectors may be cleaned and used repeatedly for this operation.

g. If a mixed string is to be run, check to determine that appropriate casing will be accessible on the pipe rack when required according to program.

h. Connectors used as tensile and lifting members should have their thread capacity carefully checked to ensure that the connector can safely support the load.

i. Care should be taken when making up pup joints and connectors to ensure that the mating threads are of the same size and type.

4.2 DRIFTING OF CASING

4.2.1 It is recommended that each length of casing be drifted for its entire length just before running, with mandrels conforming to API Specification 5CT. Casing that will not pass the drill test should be laid aside.

4.2.2 Lower or roll each piece of casing carefully to the walk without dropping. Use rope snubber if necessary. Avoid hitting casing against any part of derrick or other equipment. Provide a hold-back rope at window. For mixed or unmarked strings, a drift or "jack rabbit" should be run through each length of casing when it is picked up from the catwalk and pulled onto the derrick floor to avoid running a heavier length or one with a lesser inside diameter than called for in the casing string.

4.3 STABBING, MAKING UP, AND LOWERING

4.3.1 Do not remove thread protector from field end of casing until ready to stab.

4.3.2 If necessary, apply thread compound over the entire surface of threads just before stabbing. The brush or utensil used in applying thread compound should be kept free of foreign matter, and the compound should never be thinned.

4.3.3 In stabbing, lower casing carefully to avoid injuring threads. Stab vertically, preferably with the assistance of a man on the stabbing board. If the casing stand tilts to one side after stabbing, lift up, clean, and correct any damaged thread with a three-cornered file, then carefully remove any filings and reapply compound over the thread surface. After stabbing, the casing should be rotated very slowly at first to ensure that threads are engaging properly and not cross-threading. If spinning line is used, it should pull close to the coupling.

Note: Recommendations in 4.3.4 and 4.4.1 for casing makeup apply to the use of power tongs. For recommendations on makeup of casing with spinning lines and conventional tongs, see 4.4.2.

4.3.4 The use of power tongs for making up casing made desirable the establishment of recommended torque values for each size, weight, and grade of casing. Early studies and tests indicated that torque values are affected by a large number of variables, such as variations in taper, lead, thread height and thread form, surface finish, type of thread compound, length of thread, weight and grade of pipe, etc. In view of the number of variables and the extent that these variables, alone or in combination, could affect the relationship of torque values versus made-up position, it was evident that both applied torque and made-up position must be considered. Since the API joint pullout strength formula in API Bulletin 5C2 contains several of the variables believed to affect torque, using a modified formula to establish torque values was investigated. Torque values obtained by taking 1 percent of the calculated pullout value were found to be generally comparable to values obtained by field makeup tests using API modified thread compound in accordance with API Bulletin 5A2. Compounds other than API modified thread compound may have other torque values. This procedure was therefore used to establish the makeup torque values listed in Table 1. All values are rounded to the nearest 10 ft-lb (10 N • m). These values shall be considered as a guide only, due to the very wide variations in torque requirements that can exist for a specific connection. Because of this, it is essential that torque be related to made-up position as outlined in 4.4.1. The torque values listed in Table 1 apply to casing with zinc-plated or phosphate-coated couplings. When making up connections with tin-plated couplings, 80 percent of the listed value can be used as a guide. The listed torque values are not applicable for making up couplings with PTFE (polytetrafluoroethylene) rings. When making up round thread connections with PTFE rings, 70 percent of the listed values are recommended. Buttress connections with PTFE seal rings may make up at torque values different from those normally observed on standard buttress threads.

Note: Thread galling of gall-prone materials (martensitic chromium steels, 9 Cr and 13 Cr) occurs during movement—stabbing or pulling and makeup or breakout. Galling resistance of threads is primarily controlled in two areas—surface preparation and finishing during manufacture and careful handling practices during running and pulling. Threads and lubricant must be clean. Assembly in the horizontal position should be avoided. Connections should be turned by hand to the hand-tight position before slowly power tightening. The procedure should be reversed for disassembly.

4.4 FIELD MAKEUP

4.4.1 The following practice is recommended for field makeup of casing:

a. For round thread, sizes $4^1/_2$ through $13^3/_8$.

1. It is advisable when starting to run casing from each particular mill shipment to make up sufficient joints to determine the torque necessary to provide proper makeup. See 4.4.2 for the proper number of turns beyond hand-tight position. These values may indicate that a departure from the values listed in Table 1 is advisable. If other values are chosen, the minimum torque should be not less than 75 percent of the value selected. The maximum torque should be not more than 125 percent of the selected torque.
2. The power tong should be provided with a reliable torque gauge of known accuracy. In the initial stages of makeup, any irregularities of makeup or in speed of makeup should be observed, since these may be indicative of crossed threads, dirty or damaged threads, or other unfavorable conditions. To prevent galling when making up connections in the field, the connections should be made up at a speed not to exceed 25 rpm.
3. Continue the makeup, observing both the torque gauge and the approximately position of the coupling face with respect to the thread vanish point position.
4. The torque values shown in Tables 1, 2, and 3 have been selected to give recommended makeup under normal conditions and should be considered as satisfactory providing the face of the coupling is flush with the thread vanish point or within two thread turns, plus or minus, of the thread vanish point.
5. If the makeup is such that the thread vanish point is buried two thread turns and 75 percent of the torque

shown in Table 1 is not reached, the joint should be treated as a questionable joint as provided in 4.4.3.

6. If several threads remain exposed when the listed torque is reached, apply additional torque up to 125 percent of the value shown in Table 1. If the standoff (distance from face of coupling to the thread vanish point) is greater than three thread turns when this additional torque is reached, the joint should be treated as a questionable joint as provided in 4.4.3.

b. For buttress thread casing connections in sizes $4^1/_2$ through $13^3/_8$ OD, makeup torque values should be determined by carefully noting the torque required to make up each of several connections to the base of the triangle; then using the torque value thus established, make up the balance of the pipe of that particular weight and grade in the string.

c. For round thread and buttress thread, sizes 16, $18^5/_8$, and 20 outside diameter:

1. Makeup of sizes 16, $18^5/_8$, and 20 shall be to a position on each connection represented by the thread vanish point on 8-round thread and the base of the triangle on buttress thread using the minimum torque shown in Table 1 as a guide.

On 8-round thread casing a $^3/_8$-inch (9.5-millimeter) equilateral triangle is die stamped at a distance of L_1 + $^1/_{16}$ inch (1.6 millimeters) from each end. The base of the triangle will aid in locating the thread vanish point for basic power-tight makeup; however, the position of the coupling with respect to the base of the triangle shall not be a basis for acceptance or rejection of the product. Care shall be taken to avoid cross-threading in starting these larger connections. The tongs selected should be capable of attaining high torques [50,000 ft-lb (67,800 N • m)] for the entire run. Anticipate that maximum torque values could be five times the minimum experienced in makeup to the recommended position.

2. Joints that are questionable as to their proper makeup in 4.4.1, item a.5 or a.6 should be unscrewed and laid down to determine the cause of improper makeup. Both the pipe thread and mating coupling thread should be inspected. Damaged threads or threads that do not comply with the specification should be repaired. If damaged or out-of-tolerance threads are not found to be the cause of improper makeup, then the makeup torque should be adjusted to obtain proper makeup (see 4.4.1, item a.1). It should be noted that a thread compound with a coefficient of friction substantially different from common values may be the cause of improper makeup.

4.4.2 When conventional tongs are used for casing makeup, tighten with tongs to proper degree of tightness. The joint should be made up beyond the hand-tight position at least three turns for sizes $4^1/_2$ through 7, and at least three and one-half turns for sizes $7^5/_8$ and larger, except $9^5/_8$, and $10^3/_4$ grade P110 and size 20 grade J55 and K55, which should be made up four turns beyond hand-tight position. When using a spinning line, it is necessary to compare hand tightness with spin-up tightness. In order to do this, make up the first few joints to the hand-tight position, then back off and spin up joints to the spin-up tight position. Compare relative position of these two makeups and use this information to determine when the joint is made up the recommended number of turns beyond hand tight.

4.4.3 Joints that are questionable as to their proper tightness should be unscrewed and the casing laid down for inspection and repair. When this is done, the mating coupling should be carefully inspected for damaged threads. Parted joints should never be reused without shopping or regauging, even though the joints may have little appearance of damage.

4.4.4 If casing has a tendency to wobble unduly at its upper end when making up, indicating that the thread may not be in line with the axis of the casing, the speed of rotation should be decreased to prevent galling of threads. If wobbling should persist despite reduced rotational speed, the casing should be laid down for inspection. Serious consideration should be given before using such casing in a position in the string where a heavy tensile load is imposed.

4.4.5 In making up the field joint, it is possible for the coupling to make up slightly on the mill end. This does not indicate that the coupling on the mill end is too loose but simply that the field end has reached the tightness with which the coupling was screwed on at the manufacturer's facility.

4.4.6 Casing strings should be picked up and lowered carefully and care exercised in setting slips to avoid shock loads. Dropping a string even a short distance may loosen couplings at the bottom of the string. Care should be exercised to prevent setting casing down on bottom or otherwise placing it in compression because of the danger of buckling, particularly in that part of the well where hole enlargement has occurred.

4.4.7 Definite instructions should be available as to the design of the casing string, including the proper location of the various grades of steel, weights of casing, and types of joint. Care should be exercised to run the string in exactly the order in which it was designed. If any length cannot be clearly identified, it should be laid aside until its grade, weight, or type of joint can be positively established.

4.4.8 To facilitate running and to ensure adequate hydrostatic head to contain reservoir pressures, the casing should be periodically filled with mud while being run. A number of things govern the frequency with which filling should be accomplished: weight of pipe in the hole, mud weight, reservoir pressure, etc. In most cases, filling every six to ten lengths should suffice. In no case should the hydrostatic balance of reservoir pressure be jeopardized by too infrequent filling. Filling should be done with mud of the proper weight, using a conveniently located hose of adequate size to expedite the filling operation. A quick opening and closing plug valve on the mud hose will facilitate the operation and prevent overflow. If rubber hose is used, it is recommended that the quick-closing valve be mounted where the hose is connected to the mud line, rather than at the outlet end of the hose. It is also recommended that at least one other discharge connection be left open on the mud system to prevent buildup of excessive pressure when the quick-closing valve is closed while the pump is still running. A copper nipple at the end of the mud hose may be used to prevent damaging of the coupling threads during the filling operation.

Note: The foregoing mud fill-up practice will be unnecessary if automatic fill-up casing shoes and collars are used.

4.5 CASING LANDING PROCEDURE

Definite instructions should be provided for the proper string tension, also on the proper landing procedure after the cement has set. The purpose is to avoid critical stresses or excessive and unsafe tensile stresses at any time during the life of the well. In arriving at the proper tension and landing procedure, consideration should be given to all factors, such as well temperature and pressure, temperature developed due to cement hydration, mud temperature, and changes of temperature during producing operations. The adequacy of the original tension safety factor of the string as designed will influence the landing procedure and should be considered. If, however, after due consideration it is not considered necessary to develop special landing procedure instructions (and this probably applies to a very large majority of the wells drilled), then the procedure should be followed of landing the casing in the casing head at exactly the position in which it was hanging when the cement plug reached its lowest point or “as cemented.”

4.6 CARE OF CASING IN HOLE

Drill pipe run inside casing should be equipped with suitable drill-pipe protectors.

4.7 RECOVERY OF CASING

4.7.1 Breakout tongs should be positioned close to the coupling but not too close since a slight squashing effect where the tong dies contact the pipe surface cannot be avoided, especially if the joint is tight and/or the casing is light. Keeping a space of one-third to one-quarter of the diameter of the pipe between the tong and the coupling should normally prevent unnecessary friction in the threads. Hammering the coupling to break the joint is an injurious practice. If tapping is required, use the flat face, never the peen face of the hammer, and under no circumstances should a sledge hammer be used. Tap lightly near the middle and completely around the coupling, never near the end nor on opposite sides only.

4.7.2 Great care should be exercised to disengage all of the thread before lifting the casing out of the coupling. Do not jump casing out of the coupling.

4.7.3 All threads should be cleaned and lubricated or should be coated with a material that will minimize corrosion. Clean protectors should be placed on the tubing before it is laid down.

4.7.4 Before casing is stored or reused, pipe and thread should be inspected and defective joints marked for shopping and regauging.

4.7.5 When casing is being retrieved because of a casing failure, it is imperative to future prevention of such failures that a thorough metallurgical study be made. Every attempt should be made to retrieve the failed portion of the “as-failed” condition. When thorough metallurgical analysis reveals some facet of pipe quality to be involved in the failure, the results of the study should be reported to the API office.

4.7.6 Casing stacked in the derrick should be set on a firm wooden platform and without the bottom thread protector since the design of most protectors is not such as to support the joint or stand without damage to the field thread.

4.8 CAUSES OF CASING TROUBLES

The more common causes of casing troubles are listed in 4.8.1 through 4.8.16.

4.8.1 Improper selection for depth and pressures encountered.

4.8.2 Insufficient inspection of each length of casing or of field-shop threads.

4.8.3 Abuse in mill, transportation, and field handling.

4.8.4 Nonobservance of good rules in running and pulling casing.

4.8.5 Improper cutting of field-shop threads.

4.8.6 The use of poorly manufactured couplings for replacements and additions.

4.8.7 Improper care in storage.

4.8.8 Excessive torquing of casing to force it through tight places in the hole.

4.8.9 Pulling too hard on a string (to free it). This may loosen the couplings at the top of the string. They should be retightened with tongs before finally setting the string.

4.8.10 Rotary drilling inside casing. Setting the casing with improper tension after cementing is one of the greatest contributing causes of such failures.

4.8.11 Drill-pipe wear while drilling inside casing is particularly significant in drifted holes. Excess doglegs in deviated holes, or occasionally in straight holes where corrective measures are taken, result in concentrated bending of the casing that in turn results in excess internal wear, particularly when the doglegs are high in the hole.

4.8.12 Wire-line cutting, by swabbing or cable-tool drilling.

4.8.13 Buckling of casing in an enlarged, washed-out uncemented cavity if too much tension is released in landing.

4.8.14 Dropping a string, even a very short distance.

4.8.15 Leaky joints, under external or internal pressure, are a common trouble, and may be due to the following:

a. Improper thread compound.
b. Undertonging.
c. Dirty threads.
d. Galled threads, due to dirt, careless stabbing, damaged threads, too rapid spinning, overtonging, or wobbling during spinning or tonging operations.
e. Improper cutting of field-shop threads.
f. Pulling too hard on string.
g. Dropping string.
h. Excessive making and breaking.
i. Tonging too high on casing, especially on breaking out. This gives a bending effect that tends to gall the threads.
j. Improper joint makeup at mill.
k. Casing ovality or out-of-roundness.
l. Improper landing practice, which produces stresses in the threaded joint in excess of the yield point.

4.8.16 Corrosion. Both the inside and outside of casing can be damaged by corrosion, which can be recognized by the presence of pits or holes in the pipe. Corrosion on the outside of casing can be caused by corrosive fluids or formations in contact with the casing or by stray electric currents flowing out of the casing into the surrounding fluids or formations. Severe corrosion may also be caused by sulphate-reducing bacteria. Corrosion damage on the inside is usually caused by corrosive fluids produced from the well, but the damage can be increased by the abrasive effects of casing and tubing pumping equipment and by high fluid velocities such as those encountered in some gas-lifted wells. Internal corrosion might also be due to stray electrical currents (electrolysis) or to dissimilar metals in close contact (bimetallic galvanic corrosion).

Because corrosion may result from so many different conditions, no simple or universal remedy can be given for its control. Each corrosion problem must be treated as an individual case and a solution attempted in the light of the known corrosion factors and operating conditions. The condition of the casing can be determined by visual or optical-instrument inspections. Where these are not practical, a casing-caliper survey can be made to determine the condition of the inside surfaces. No tools have yet been designed for determining the condition of the outside of casing in a well. Internal casing-caliper surveys indicate the extent, location, and severity of corrosion. On the basis of the industry's experience to date, the following practices and measures can be used to control corrosion of casing:

a. Where external casing corrosion is known to occur or stray electrical current surveys indicate that relatively high currents are entering the well, the following practices can be employed:
   1. Good cementing practices, including the use of centralizers, scratchers, and adequate amounts of cement to keep corrosive fluids from contact with the outside of the casing.
   2. Electrical insulation of flow lines from wells by the use of nonconducting flange assemblies to reduce or prevent electrical currents from entering the well.
   3. The use of highly alkaline mud or mud treated with a bactericide as a completion fluid will help alleviate corrosion caused by sulfate-reducing bacteria.
   4. A properly designed cathodic protection system similar to that used for line pipe, which can alleviate external casing corrosion. Protection criteria for casing differ somewhat from the criteria used for line pipe. Literature on external casing corrosion or persons competent in this field should be consulted for proper protection criteria.

b. Where internal corrosion is known to exist, the following practices can be employed:
   1. In flowing wells, packing the annulus with fresh water or low-salinity alkaline muds. (It may be preferable in some flowing wells to depend upon inhibitors to protect the inside of the casing and the tubing.)
   2. In pumping wells, avoiding the use of casing pumps. Ordinarily, pumping wells should be tubed as close to bottom as practical, regardless of the position of the pump, to minimize the damage to the casing from corrosive fluids.
   3. Using inhibitors to protect the inside of the casing against corrosion.

c. To determine the value and effectiveness of the above practices and measures, cost and equipment-failure records can be compared before and after application of control measures. Inhibitor effectiveness may be checked also by means of caliper surveys, visual examinations of readily accessible pieces of equipment, and water analyses for iron content. Coupons may also be helpful in determining whether sufficient inhibitor is being used. When lacking previous experience with any of the above measures, they should be used cautiously and on a limited scale until appraised for the particular operating conditions.

d. In general, all new areas should be considered as being potentially corrosive and investigations should be initiated early in the life of a field, and repeated periodically, to detect and localize corrosion before it has done destructive damage. These investigations should cover: (1) a complete chemical analysis of the effluent water, including pH, iron, hydrogen sulfide, organic acids, and any other substances that influence or indicate the degree of corrosion. An analysis of the produced gas for carbon dioxide and hydrogen sulfide is also desirable; (2) corrosion rate tests by using coupons of the same materials as in the well; and (3) the use of caliper or optical-instrument inspections. Where conditions favorable to corrosion exist, a qualified corrosion engineer should be consulted. Particular attention should be given to mitigation of corrosion where the probable life of subsurface equipment is less than the time expected to deplete a well.

e. When H_2S is present in the well fluids, casing of high yield strength may be subject to sulfide corrosion cracking. The concentration of H_2S necessary to cause cracking in different strength materials is not yet well defined. Literature on sulfide corrosion or persons competent in this field should be consulted.

5 Running and Pulling Tubing

5.1 PREPARATION AND INSPECTION BEFORE RUNNING

5.1.1 New tubing is delivered free of injurious defects as defined in API Specification 5CT and within the practical limits of the inspection procedures therein prescribed. Some users have found that, for a limited number of critical well applications, these procedures do not result in tubing sufficiently free of defects to meet their needs for such critical applications. Various nondestructive inspection services have been employed by users to ensure that the desired quality of tubing is being run. In view of this practice, it is suggested that the individual user:

a. Familiarize himself with inspection practices specified in the standards and employed by the respective manufacturers, and with the definition of "injurious defect" contained in the standards.

b. Thoroughly evaluate any nondestructive inspection to be used by him on API tubular goods to assure himself that the inspection does in fact correctly locate and differentiate injurious defects from other variables that can be and frequently are sources of misleading "defect" signals with such inspection methods.

CAUTION: Due to the permissible tolerance on the outside diameter immediately behind the tubing upset, the user is cautioned that difficulties may occur when wrap-around seal-type hangers are installed on tubing manufactured on the high side of the tolerance; therefore, it is recommended that the user select the joint of tubing to be installed at the top of the string.

5.1.2 All tubing, whether new, used, or reconditioned, should always be handled with thread protectors in place. Tubing should be handled at all times on racks or on wooden or metal surfaces free of rocks, sand, or dirt other than normal drilling mud. When lengths of tubing are inadvertently dragged in the dirt, the threads should be recleaned and serviced again as outlined in 5.1.9.

5.1.3 Before running in the hole for the first time, tubing should be drifted with an API drift mandrel to ensure passage of pumps, swabs, and packers.

5.1.4 Elevators should be in good repair and should have links of equal length.

5.1.5 Slip-type elevators are recommended when running special clearance couplings, especially those beveled on the lower end.

5.1.6 Elevators should be examined to note if latch fitting is complete.

5.1.7 Spider slips that will not crush the tubing should be used. Slips should be examined before using to see that they are working together.

Note: Slip and tong marks are injurious. Every possible effort should be made to keep such damage at a minimum by using proper up-to-date equipment.

5.1.8 Tubing tongs that will not crush the tubing should be used on the body of the tubing and should fit properly to avoid unnecessary cutting of the pipe wall. Tong dies should fit properly and conform to the curvature of the tubing. The use of pipe wrenches is not recommended.

5.1.9 The following precautions should be taken in the preparation of tubing threads:

a. Immediately before running, remove protectors from both field end and coupling end and clean threads thoroughly, repeating as additional rows become uncovered.

b. Carefully inspect the threads. Those found damaged, even slightly, should be laid aside unless satisfactory means are available for correcting thread damage.

c. The length of each piece of tubing shall be measured prior to running. A steel tape calibrated in decimal feet (millimeters) to the nearest 0.01 feet (millimeters) 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 or the box stops when the joint is made up power tight. The total of the individual lengths so measured will represent the unloaded length of the tubing string.

The actual length under tension in the hole can be obtained by consulting graphs that are prepared for this purpose and are available in most pipe handbooks.

d. Place clean protectors on field end of the pipe so that thread will not be damaged while rolling pipe onto the rack and pulling into the derrick. Several thread protectors may be cleaned and used repeatedly for this operation.

e. Check each coupling for makeup. If the stand-off is abnormally great, check the coupling for tightness. Loose couplings should be removed, the thread thoroughly cleaned, fresh compound applied over the entire thread surfaces, then

Table 1—Casing Makeup Torque Guideline, 8-Round Thread Casing

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Outside Diameter			Torque			
Designation		D	Dm		ST&C		LT&C	
Size	Weight	(in.)	(mm)	Grade	ft-lb	N • m	ft-lb	N • m
4.500	9.50	4.500	114.30	H40	770	1040	--	--
4.500	9.50	4.500	114.30	J55	1010	1380	--	--
4.500	10.50	4.500	114.30	J55	1320	1790	--	--
4.500	11.60	4.500	114.30	J55	1540	2090	1620	2200
4.500	9.50	4.500	114.30	K55	1120	1520	--	--
4.500	10.50	4.500	114.30	K55	1460	1980	--	--
4.500	11.60	4.500	114.30	K55	1700	2310	1800	2430
4.500	9.50	4.500	114.30	M65	1180	1600	--	--
4.500	10.50	4.500	114.30	M65	1540	2090	--	--
4.500	11.60	4.500	114.30	M65	--	--	1880	2550
4.500	13.50	4.500	114.30	M65	--	--	2280	3090
4.500	11.60	4.500	114.30	L80	--	--	2230	3030
4.500	13.50	4.500	114.30	L80	--	--	2710	3670
4.500	11.60	4.500	114.30	N80	--	--	2280	3090
4.500	13.50	4.500	114.30	N80	--	--	2760	3740
4.500	11.60	4.500	114.30	C90	--	--	2450	3320
4.500	13.50	4.500	114.30	C90	--	--	2970	4030
4.500	11.60	4.500	114.30	C95	--	--	2580	3500
4.500	13.50	4.500	114.30	C95	--	--	3130	4240
4.500	11.60	4.500	114.30	T95	--	--	2580	3500
4.500	13.50	4.500	114.30	T95	--	--	3130	4240
4.500	11.60	4.500	114.30	P110	--	--	3020	4100
4.500	13.50	4.500	114.30	P110	--	--	3660	4960
4.500	15.10	4.500	114.30	P110	--	--	4400	5960
4.500	15.10	4.500	114.30	Q125	--	--	4910	6650
5.000	11.50	5.000	127.00	J55	1330	1810	--	--
5.000	13.00	5.000	127.00	J55	1690	2290	1820	2470
5.000	15.00	5.000	127.00	J55	2070	2800	2230	3020
5.000	11.50	5.000	127.00	K55	1470	1990	--	--
5.000	13.00	5.000	127.00	K55	1860	2520	2010	2730
5.000	15.00	5.000	127.00	K55	2280	3090	2460	3340

Table 1—Casing Makeup Torque Guideline, 8-Round Thread Casing (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Outside Diameter			Torque			
Designation		D	Dm		ST&C		LT&C	
Size	Weight	(in.)	(mm)	Grade	ft-lb	N • m	ft-lb	N • m
5.000	11.50	5.000	127.00	M65	1550	2100	--	--
5.000	13.00	5.000	127.00	M65	1960	2660	2120	2870
5.000	15.00	5.000	127.00	M65	--	--	2590	3520
5.000	18.00	5.000	127.00	M65	--	--	3310	4480
5.000	21.40	5.000	127.00	M65	--	--	4090	5550
5.000	15.00	5.000	127.00	L80	--	--	3080	4170
5.000	18.00	5.000	127.00	L80	--	--	3930	5320
5.000	21.40	5.000	127.00	L80	--	--	4860	6590
5.000	23.20	5.000	127.00	L80	--	--	5350	7260
5.000	24.10	5.000	127.00	L80	--	--	5610	7610
5.000	15.00	5.000	127.00	N80	--	--	3140	4250
5.000	18.00	5.000	127.00	N80	--	--	4000	5420
5.000	21.40	5.000	127.00	N80	--	--	4950	6710
5.000	23.20	5.000	127.00	N80	--	--	5450	7400
5.000	24.10	5.000	127.00	N80	--	--	5720	7760
5.000	15.00	5.000	127.00	C90	--	--	3380	4590
5.000	18.00	5.000	127.00	C90	--	--	4310	5850
5.000	21.40	5.000	127.00	C90	--	--	5340	7240
5.000	23.20	5.000	127.00	C90	--	--	5880	7980
5.000	24.10	5.000	127.00	C90	--	--	6170	8370
5.000	15.00	5.000	127.00	C95	--	--	3560	4830
5.000	18.00	5.000	127.00	C95	--	--	4550	6160
5.000	21.40	5.000	127.00	C95	--	--	5620	7630
5.000	23.20	5.000	127.00	C95	--	--	6200	8400
5.000	24.10	5.000	127.00	C95	--	--	6500	8810
5.000	15.00	5.000	127.00	T95	--	--	3560	4830
5.000	18.00	5.000	127.00	T95	--	--	4550	6160
5.000	21.40	5.000	127.00	T95	--	--	5620	7630
5.000	23.20	5.000	127.00	T95	--	--	6200	8400
5.000	24.10	5.000	127.00	T95	--	--	6500	8810
5.000	15.00	5.000	127.00	P110	--	--	4170	5650
5.000	18.00	5.000	127.00	P110	--	--	5310	7210
5.000	21.40	5.000	127.00	P110	--	--	6580	8920
5.000	23.20	5.000	127.00	P110	--	--	7250	9830
5.000	24.10	5.000	127.00	P110	--	--	7600	10,310
5.000	18.00	5.000	127.00	Q125	--	--	5930	8050
5.000	21.40	5.000	127.00	Q125	--	--	7340	9960
5.000	23.20	5.000	127.00	Q125	--	--	8090	10,970
5.000	24.10	5.000	127.00	Q125	--	--	8490	11,510

Table 1—Casing Makeup Torque Guideline, 8-Round Thread Casing (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Outside Diameter			Torque			
Designation		D	Dm		ST&C			LT&C
Size	Weight	(in.)	(mm)	Grade	ft-lb	N • m	ft-lb	N • m
5.500	14.00	5.500	139.70	H40	1300	1760	--	--
5.500	14.00	5.500	139.70	J55	1720	2330	--	--
5.500	15.50	5.500	139.70	J55	2020	2730	2170	2940
5.500	17.00	5.500	139.70	J55	2290	3110	2470	3340
5.500	14.00	5.500	139.70	K55	1890	2560	--	--
5.500	15.50	5.500	139.70	K55	2220	3000	2390	3240
5.500	17.00	5.500	139.70	K55	2520	3410	2720	3680
5.500	14.00	5.500	139.70	M65	2000	2710	--	--
5.500	15.50	5.500	139.70	M65	2350	3180	2530	3430
5.500	17.00	5.500	139.70	M65	--	--	2870	3890
5.500	20.00	5.500	139.70	M65	--	--	3530	4790
5.500	23.00	5.500	139.70	M65	--	--	4150	5620
5.500	17.00	5.500	139.70	L80	--	--	3410	4630
5.500	20.00	5.500	139.70	L80	--	--	4200	5700
5.500	23.00	5.500	139.70	L80	--	--	4930	6690
5.500	17.00	5.500	139.70	N80	--	--	3480	4710
5.500	20.00	5.500	139.70	N80	--	--	4280	5800
5.500	23.00	5.500	139.70	N80	--	--	5020	6810
5.500	17.00	5.500	139.70	C90	--	--	3750	5090
5.500	20.00	5.500	139.70	C90	--	--	4620	6270
5.500	23.00	5.500	139.70	C90	--	--	5430	7360
5.500	17.00	5.500	139.70	C95	--	--	3960	5360
5.500	20.00	5.500	139.70	C95	--	--	4870	6600
5.500	23.00	5.500	139.70	C95	--	--	5720	7750
5.500	17.00	5.500	139.70	T95	--	--	3960	5360
5.500	20.00	5.500	139.70	T95	--	--	4870	6600
5.500	23.00	5.500	139.70	T95	--	--	5720	7750
5.500	17.00	5.500	139.70	P110	--	--	4620	6270
5.500	20.00	5.500	139.70	P110	--	--	5690	7720
5.500	23.00	5.500	139.70	P110	--	--	6680	9060
5.500	23.00	5.500	139.70	Q125	--	--	7470	10120
6.625	20.00	6.625	168.28	H40	1840	2490	--	--
6.625	20.00	6.625	168.28	J55	2450	3320	2660	3600
6.625	24.00	6.625	168.28	J55	3140	4250	3400	4620

Table 1—Casing Makeup Torque Guideline, 8-Round Thread Casing (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Outside Diameter			Torque			
Designation		D	Dm		ST&C			LT&C
Size	Weight	(in.)	(mm)	Grade	ft-lb	N • m	ft-lb	N • m
6.625	20.00	6.625	168.28	K55	2670	3620	2900	3940
6.625	24.00	6.625	168.28	K55	3420	4640	3720	5050
6.625	20.00	6.625	168.28	M65	2850	3870	3090	4190
6.625	24.00	6.625	168.28	M65	--	--	3960	5380
6.625	28.00	6.625	168.28	M65	--	--	4830	6550
6.625	24.00	6.625	168.28	L80	--	--	4730	6410
6.625	28.00	6.625	168.28	L80	--	--	5760	7810
6.625	32.00	6.625	168.28	L80	--	--	6660	9030
6.625	24.00	6.625	168.28	N80	--	--	4810	6520
6.625	28.00	6.625	168.28	N80	--	--	5860	7940
6.625	32.00	6.625	168.28	N80	--	--	6780	9190
6.625	24.00	6.625	168.28	C90	--	--	5210	7060
6.625	28.00	6.625	168.28	C90	--	--	6350	8610
6.625	32.00	6.625	168.28	C90	--	--	7340	9950
6.625	24.00	6.625	168.28	C95	--	--	5490	7440
6.625	28.00	6.625	168.28	C95	--	--	6690	9070
6.625	32.00	6.625	168.28	C95	--	--	7740	10,490
6.625	24.00	6.625	168.28	T95	--	--	5490	7440
6.625	28.00	6.625	168.28	T95	--	--	6690	9070
6.625	32.00	6.625	168.28	T95	--	--	7740	10,490
6.625	24.00	6.625	168.28	P110	--	--	6410	8690
6.625	28.00	6.625	168.28	P110	--	--	7810	10,590
6.625	32.00	6.625	168.28	P110	--	--	9040	12,250
6.625	32.00	6.625	168.28	Q125	--	--	10,110	13,710
7.000	17.00	7.000	177.80	H40	1220	1650	--	--
7.000	20.00	7.000	177.80	H40	1760	2380	--	--
7.000	20.00	7.000	177.80	J55	2340	3170	--	--
7.000	23.00	7.000	177.80	J55	2840	3850	3130	4240
7.000	26.00	7.000	177.80	J55	3340	4530	3670	4980
7.000	20.00	7.000	177.80	K55	2540	3450	--	--
7.000	23.00	7.000	177.80	K55	3090	4190	3410	4630
7.000	26.00	7.000	177.80	K55	3640	4930	4010	5440
7.000	20.00	7.000	177.80	M65	2730	3690	--	--
7.000	23.00	7.000	177.80	M65	--	--	3640	4940
7.000	26.00	7.000	177.80	M65	--	--	4280	5800

Table 1—Casing Makeup Torque Guideline, 8-Round Thread Casing (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Outside Diameter			Torque			
Designation		D	Dm		ST&C		LT&C	
Size	Weight	(in.)	(mm)	Grade	ft-lb	N • m	ft-lb	N • m
7.000	29.00	7.000	177.80	M65	--	--	4920	6680
7.000	32.00	7.000	177.80	M65	--	--	5540	7520
7.000	23.00	7.000	177.80	L80	--	--	4350	5890
7.000	26.00	7.000	177.80	L80	--	--	5110	6930
7.000	29.00	7.000	177.80	L80	--	--	5870	7960
7.000	32.00	7.000	177.80	L80	--	--	6610	8970
7.000	35.00	7.000	177.80	L80	--	--	7340	9950
7.000	38.00	7.000	177.80	L80	--	--	8010	10,860
7.000	23.00	7.000	177.80	N80	--	--	4420	5990
7.000	26.00	7.000	177.80	N80	--	--	5190	7040
7.000	29.00	7.000	177.80	N80	--	--	5970	8100
7.000	32.00	7.000	177.80	N80	--	--	6720	9110
7.000	35.00	7.000	177.80	N80	--	--	7460	10,120
7.000	38.00	7.000	177.80	N80	--	--	8140	11,040
7.000	23.00	7.000	177.80	C90	--	--	4790	6500
7.000	26.00	7.000	177.80	C90	--	--	5630	7630
7.000	29.00	7.000	177.80	C90	--	--	6480	8780
7.000	32.00	7.000	177.80	C90	--	--	7290	9890
7.000	35.00	7.000	177.80	C90	--	--	8090	10,970
7.000	38.00	7.000	177.80	C90	--	--	8830	11,970
7.000	23.00	7.000	177.80	C95	--	--	5050	6850
7.000	26.00	7.000	177.80	C95	--	--	5930	8050
7.000	29.00	7.000	177.80	C95	--	--	6830	9250
7.000	32.00	7.000	177.80	C95	--	--	7680	10,420
7.000	35.00	7.000	177.80	C95	--	--	8530	11,560
7.000	38.00	7.000	177.80	C95	--	--	9310	12,620
7.000	23.00	7.000	177.80	T95	--	--	5050	6850
7.000	26.00	7.000	177.80	T95	--	--	5930	8050
7.000	29.00	7.000	177.80	T95	--	--	6830	9250
7.000	32.00	7.000	177.80	T95	--	--	7680	10,420
7.000	35.00	7.000	177.80	T95	--	--	8530	11,560
7.000	38.00	7.000	177.80	T95	--	--	9310	12,620
7.000	26.00	7.000	177.80	P110	--	--	6930	9390
7.000	29.00	7.000	177.80	P110	--	--	7970	10,800
7.000	32.00	7.000	177.80	P110	--	--	8970	12,160
7.000	35.00	7.000	177.80	P110	--	--	9960	13,500
7.000	38.00	7.000	177.80	P110	--	--	10,870	14,730
7.000	35.00	7.000	177.80	Q125	--	--	11,150	15,110
7.000	38.00	7.000	177.80	Q125	--	--	12,160	16,490

Table 1—Casing Makeup Torque Guideline, 8-Round Thread Casing (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Outside Diameter			Torque			
Designation		D	Dm		ST&C		LT&C	
Size	Weight	(in.)	(mm)	Grade	ft-lb	N • m	ft-lb	N • m
7.625	24.00	7.625	193.68	H40	2120	2870	--	--
7.625	26.40	7.625	193.68	J55	3150	4270	3460	4690
7.625	26.40	7.625	193.68	K55	3420	4640	3770	5110
7.625	26.40	7.625	193.68	M65	3680	4980	4040	5470
7.625	29.70	7.625	193.68	M65	--	--	4740	6430
7.625	33.70	7.625	193.68	M65	--	--	5560	7540
7.625	26.40	7.625	193.68	L80	--	--	4820	6530
7.625	29.70	7.625	193.68	L80	--	--	5670	7680
7.625	33.70	7.625	193.68	L80	--	--	6640	9000
7.625	39.00	7.625	193.68	L80	--	--	7860	10,650
7.625	42.80	7.625	193.68	L80	--	--	8910	12,090
7.625	45.30	7.625	193.68	L80	--	--	9470	12,840
7.625	47.10	7.625	193.68	L80	--	--	9970	13,520
7.625	26.40	7.625	193.68	N80	--	--	4900	6640
7.625	29.70	7.625	193.68	N80	--	--	5750	7800
7.625	33.70	7.625	193.68	N80	--	--	6740	9140
7.625	39.00	7.625	193.68	N80	--	--	7980	10,820
7.625	42.80	7.625	193.68	N80	--	--	9060	12,280
7.625	45.30	7.625	193.68	N80	--	--	9620	13,040
7.625	47.10	7.625	193.68	N80	--	--	10,130	13,730
7.625	26.40	7.625	193.68	C90	--	--	5320	7210
7.625	29.70	7.625	193.68	C90	--	--	6250	8470
7.625	33.70	7.625	193.68	C90	--	--	7330	9930
7.625	39.00	7.625	193.68	C90	--	--	8670	11,750
7.625	42.80	7.625	193.68	C90	--	--	9840	13,330
7.625	45.30	7.625	193.68	C90	--	--	10,450	14,160
7.625	47.10	7.625	193.68	C90	--	--	11,000	14,910
7.625	26.40	7.625	193.68	C95	--	--	5600	7600
7.625	29.70	7.625	193.68	C95	--	--	6590	8930
7.625	33.70	7.625	193.68	C95	--	--	7720	10,470
7.625	39.00	7.625	193.68	C95	--	--	9140	12,390
7.625	42.80	7.625	193.68	C95	--	--	10,370	14,050
7.625	45.30	7.625	193.68	C95	--	--	11,010	14,930
7.625	47.10	7.625	193.68	C95	--	--	11,590	15,720
7.625	26.40	7.625	193.68	T95	--	--	5600	7600
7.625	29.70	7.625	193.68	T95	--	--	6590	8930
7.625	33.70	7.625	193.68	T95	--	--	7720	10,470
7.625	39.00	7.625	193.68	T95	--	--	9140	12,390
7.625	42.80	7.625	193.68	T95	--	--	10,370	14,050

Table 1—Casing Makeup Torque Guideline, 8-Round Thread Casing (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Outside Diameter			Torque			
Designation		D	Dm		ST&C		LT&C	
Size	Weight	(in.)	(mm)	Grade	ft-lb	N • m	ft-lb	N • m
7.625	45.30	7.625	193.68	T95	--	--	11,010	14,930
7.625	47.10	7.625	193.68	T95	--	--	11,590	15,720
7.625	29.70	7.625	193.68	P110	--	--	7690	10,420
7.625	33.70	7.625	193.68	P110	--	--	9010	12,220
7.625	39.00	7.625	193.68	P110	--	--	10,660	14,460
7.625	42.80	7.625	193.68	P110	--	--	12,100	16,440
7.625	45.30	7.625	193.68	P110	--	--	12,850	17,420
7.625	47.10	7.625	193.68	P110	--	--	13,530	18,340
7.625	39.00	7.625	193.68	Q125	--	--	11,940	16,190
7.625	42.80	7.625	193.68	Q125	--	--	13,550	18,370
7.625	45.30	7.625	193.68	Q125	--	--	14,390	19,520
7.625	47.10	7.625	193.68	Q125	--	--	15,150	20,540
8.625	28.00	8.625	219.08	H40	2330	3150	--	--
8.625	32.00	8.625	219.08	H40	2790	3780	--	--
8.625	24.00	8.625	219.08	J55	2440	3310	--	--
8.625	32.00	8.625	219.08	J55	3720	5050	4170	5660
8.625	36.00	8.625	219.08	J55	4340	5880	4860	6590
8.625	24.00	8.625	219.08	K55	2630	3570	--	--
8.625	32.00	8.625	219.08	K55	4020	5460	4520	6130
8.625	36.00	8.625	219.08	K55	4680	6350	5260	7140
8.625	24.00	8.625	219.08	M65	2850	3860	--	--
8.625	28.00	8.625	219.08	M65	3620	4910	--	--
8.625	32.00	8.625	219.08	M65	4350	5890	4870	6600
8.625	36.00	8.625	219.08	M65	5060	6860	5670	7690
8.625	40.00	8.625	219.08	M65	--	--	6490	8800
8.625	36.00	8.625	219.08	L80	--	--	6780	9190
8.625	40.00	8.625	219.08	L80	--	--	7760	10,530
8.625	44.00	8.625	219.08	L80	--	--	8740	11,840
8.625	49.00	8.625	219.08	L80	--	--	9830	13,320
8.625	36.00	8.625	219.08	N80	--	--	6880	9330
8.625	40.00	8.625	219.08	N80	--	--	7880	10,680
8.625	44.00	8.625	219.08	N80	--	--	8870	12,020
8.625	49.00	8.625	219.08	N80	--	--	9970	13,520
8.625	36.00	8.625	219.08	C90	--	--	7490	10,150
8.625	40.00	8.625	219.08	C90	--	--	8580	11,630
8.625	44.00	8.625	219.08	C90	--	--	9650	13,080
8.625	49.00	8.625	219.08	C90	--	--	10,850	14,710

Table 1—Casing Makeup Torque Guideline, 8-Round Thread Casing (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Outside Diameter			Torque			
Designation		D	Dm		ST&C		LT&C	
Size	Weight	(in.)	(mm)	Grade	ft-lb	N • m	ft-lb	N • m
8.625	36.00	8.625	219.08	C95	--	--	7890	10,700
8.625	40.00	8.625	219.08	C95	--	--	9040	12,260
8.625	44.00	8.625	219.08	C95	--	--	10,170	13,790
8.625	49.00	8.625	219.08	C95	--	--	11,440	15,510
8.625	36.00	8.625	219.08	T95	--	--	7890	10,700
8.625	40.00	8.625	219.08	T95	--	--	9040	12,260
8.625	44.00	8.625	219.08	T95	--	--	10,170	13,790
8.625	49.00	8.625	219.08	T95	--	--	11,440	15,510
8.625	40.00	8.625	219.08	P110	--	--	10,550	14,300
8.625	44.00	8.625	219.08	P110	--	--	11,860	16,090
8.625	49.00	8.625	219.08	P110	--	--	13,350	18,100
8.625	49.00	8.625	219.08	Q125	--	--	14,960	20,280
9.625	32.30	9.625	244.48	H40	2540	3440	--	--
9.625	36.00	9.625	244.48	H40	2940	3990	--	--
9.625	36.00	9.625	244.48	J55	3940	5340	4530	6140
9.625	40.00	9.625	244.48	J55	4520	6120	5200	7050
9.625	36.00	9.625	244.48	K55	4230	5740	4890	6630
9.625	40.00	9.625	244.48	K55	4860	6590	5610	7610
9.625	36.00	9.625	244.48	M65	4600	6230	5290	7170
9.625	40.00	9.625	244.48	M65	5280	7150	6070	8230
9.625	43.50	9.625	244.48	M65	--	--	6790	9210
9.625	47.00	9.625	244.48	M65	--	--	7450	10100
9.625	40.00	9.625	244.48	L80	--	--	7270	9860
9.625	43.50	9.625	244.48	L80	--	--	8130	11,030
9.625	47.00	9.625	244.48	L80	--	--	8930	12,100
9.625	53.50	9.625	244.48	L80	--	--	10,470	14,190
9.625	58.40	9.625	244.48	L80	--	--	11,510	15,600
9.625	40.00	9.625	244.48	N80	--	--	7370	10,000
9.625	43.50	9.625	244.48	N80	--	--	8250	11,190
9.625	47.00	9.625	244.48	N80	--	--	9050	12,270
9.625	53.50	9.625	244.48	N80	--	--	10,620	14,390
9.625	58.40	9.625	244.48	N80	--	--	11,670	15,820
9.625	40.00	9.625	244.48	C90	--	--	8040	10,900
9.625	43.50	9.625	244.48	C90	--	--	8990	12,190
9.625	47.00	9.625	244.48	C90	--	--	9870	13,380
9.625	53.50	9.625	244.48	C90	--	--	11,570	15,690
9.625	58.40	9.625	244.48	C90	--	--	12,720	17,250

Table 1—Casing Makeup Torque Guideline, 8-Round Thread Casing (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Outside Diameter			Torque			
Designation		D	Dm		ST&C		LT&C	
Size	Weight	(in.)	(mm)	Grade	ft-lb	N • m	ft-lb	N • m
9.625	40.00	9.625	244.48	C95	--	--	8470	11,490
9.625	43.50	9.625	244.48	C95	--	--	9480	12,850
9.625	47.00	9.625	244.48	C95	--	--	10,400	14,100
9.625	53.50	9.625	244.48	C95	--	--	12,200	16,540
9.625	58.40	9.625	244.48	C95	--	--	13,410	18,180
9.625	40.00	9.625	244.48	T95	--	--	8470	11,490
9.625	43.50	9.625	244.48	T95	--	--	9480	12,850
9.625	47.00	9.625	244.48	T95	--	--	10,400	14,100
9.625	53.50	9.625	244.48	T95	--	--	12,200	16,540
9.625	58.40	9.625	244.48	T95	--	--	13,410	18,180
9.625	43.50	9.625	244.48	P110	--	--	11,050	14,980
9.625	47.00	9.625	244.48	P110	--	--	12,130	16,440
9.625	53.50	9.625	244.48	P110	--	--	14,220	19,280
9.625	58.40	9.625	244.48	P110	--	--	15,630	21,200
9.625	47.00	9.625	244.48	Q125	--	--	13,600	18,440
9.625	53.50	9.625	244.48	Q125	--	--	15,950	21,630
9.625	58.40	9.625	244.48	Q125	--	--	17,540	23,770
10.750	32.75	10.750	273.05	H40	2050	2790	--	--
10.750	40.50	10.750	273.05	H40	3140	4250	--	--
10.750	40.50	10.750	273.05	J55	4200	5700	--	--
10.750	45.50	10.750	273.05	J55	4930	6680	--	--
10.750	51.00	10.750	273.05	J55	5650	7660	--	--
10.750	40.50	10.750	273.05	K55	4500	6100	--	--
10.750	45.50	10.750	273.05	K55	5280	7160	--	--
10.750	51.00	10.750	273.05	K55	6060	8210	--	--
10.750	40.50	10.750	273.05	M65	4910	6660	--	--
10.750	45.50	10.750	273.05	M65	5760	7810	--	--
10.750	51.00	10.750	273.05	M65	6610	8960	--	--
10.750	55.50	10.750	273.05	M65	6610	8960	--	--
10.750	51.00	10.750	273.05	L80	7940	10760	--	--
10.750	55.50	10.750	273.05	L80	8840	11990	--	--
10.750	51.00	10.750	273.05	N80	8040	10900	--	--
10.750	55.50	10.750	273.05	N80	8950	12140	--	--
10.750	51.00	10.750	273.05	C90	8790	11920	--	--
10.750	55.50	10.750	273.05	C90	9790	13270	--	--
10.750	60.70	10.750	273.05	C90	10890	14770	--	--
10.750	65.70	10.750	273.05	C90	11980	16240	--	--

Table 1—Casing Makeup Torque Guideline, 8-Round Thread Casing (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Outside Diameter			Torque			
Designation		D	Dm		ST&C		LT&C	
Size	Weight	(in.)	(mm)	Grade	ft-lb	N • m	ft-lb	N • m
10.750	51.00	10.750	273.05	C95	9270	12560	--	--
10.750	55.50	10.750	273.05	C95	10320	13990	--	--
10.750	51.00	10.750	273.05	T95	9270	12560	--	--
10.750	55.50	10.750	273.05	T95	10320	13990	--	--
10.750	60.70	10.750	273.05	T95	11480	15570	--	--
10.750	65.70	10.750	273.05	T95	12630	17130	--	--
10.750	51.00	10.750	273.05	P110	10790	14630	--	--
10.750	55.50	10.750	273.05	P110	12020	16300	--	--
10.750	60.70	10.750	273.05	P110	13370	18130	--	--
10.750	65.70	10.750	273.05	P110	14710	19950	--	--
10.750	60.70	10.750	273.05	Q125	15020	20360	--	--
10.750	65.70	10.750	273.05	Q125	16520	22400	--	--
11.750	42.00	11.750	298.45	H40	3070	4170	--	--
11.750	47.00	11.750	298.45	J55	4770	6460	--	--
11.750	54.00	11.750	298.45	J55	5680	7700	--	--
11.750	60.00	11.750	298.45	J55	6490	8800	--	--
11.750	47.00	11.750	298.45	K55	5090	6900	--	--
11.750	54.00	11.750	298.45	K55	6060	8220	--	--
11.750	60.00	11.750	298.45	K55	6930	9400	--	--
11.750	47.00	11.750	298.45	M65	5570	7560	--	--
11.750	54.00	11.750	298.45	M65	6640	9000	--	--
11.750	60.00	11.750	298.45	M65	7590	10290	--	--
11.750	60.00	11.750	298.45	L80	9130	12370	--	--
11.750	60.00	11.750	298.45	N80	9240	12520	--	--
11.750	60.00	11.750	298.45	C90	10110	13710	--	--
11.750	60.00	11.750	298.45	T95	10660	14460	--	--
11.750	60.00	11.750	298.45	C95	10660	14460	--	--
11.750	60.00	11.750	298.45	P110	12420	16830	--	--
11.750	60.00	11.750	298.45	Q125	13950	18920	--	--
13.375	48.00	13.375	339.73	H40	3220	4370	--	--

Table 1—Casing Makeup Torque Guideline, 8-Round Thread Casing (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Outside Diameter				Torque		
Designation		D	Dm		ST&C		LT&C	
Size	Weight	(in.)	(mm)	Grade	ft-lb	N • m	ft-lb	N • m
13.375	54.50	13.375	339.73	J55	5140	6970	--	--
13.375	61.00	13.375	339.73	J55	5950	8070	--	--
13.375	68.00	13.375	339.73	J55	6750	9160	--	--
13.375	54.50	13.375	339.73	K55	5470	7410	--	--
13.375	61.00	13.375	339.73	K55	6330	8580	--	--
13.375	68.00	13.375	339.73	K55	7180	9740	--	--
13.375	54.50	13.375	339.73	M65	6020	8160	--	--
13.375	61.00	13.375	339.73	M65	6970	9440	--	--
13.375	68.00	13.375	339.73	M65	7910	10720	--	--
13.375	68.00	13.375	339.73	L80	9520	12910	--	--
13.375	72.00	13.375	339.73	L80	10290	13950	--	--
13.375	68.00	13.375	339.73	N80	9630	13060	--	--
13.375	72.00	13.375	339.73	N80	10400	14110	--	--
13.375	68.00	13.375	339.73	C90	10570	14330	--	--
13.375	72.00	13.375	339.73	C90	11420	15480	--	--
13.375	68.00	13.375	339.73	C95	11140	15110	--	--
13.375	72.00	13.375	339.73	C95	12040	16320	--	--
13.375	68.00	13.375	339.73	T95	11140	15110	--	--
13.375	72.00	13.375	339.73	T95	12040	16320	--	--
13.375	68.00	13.375	339.73	P110	12970	17580	--	--
13.375	72.00	13.375	339.73	P110	14010	18990	--	--
13.375	72.00	13.375	339.73	Q125	15760	21360	--	--
16.000	65.00	16.000	406.40	H40	4390	5950	--	--
16.000	75.00	16.000	406.40	J55	7100	9630	--	--
16.000	84.00	16.000	406.40	J55	8170	11080	--	--
16.000	75.00	16.000	406.40	K55	7520	10190	--	--
16.000	84.00	16.000	406.40	K55	8650	11730	--	--
16.000	75.00	16.000	406.40	M65	8320	11280	--	--
16.000	84.00	16.000	406.40	M65	9570	12980	--	--
18.625	87.50	18.625	473.08	H40	5590	7580	--	--
18.625	87.50	18.625	473.08	J55	7540	10220	--	--
18.625	87.50	18.625	473.08	K55	7940	10770	--	--

Table 1—Casing Makeup Torque Guideline, 8-Round Thread Casing (Continued)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Outside Diameter			Torque			
Designation		D	Dm		ST&C		LT&C	
Size	Weight	(in.)	(mm)	Grade	ft-lb	N • m	ft-lb	N • m
18.625	87.50	18.625	473.08	M65	8840	11980	--	--
20.000	94.00	20.000	508.00	H40	5810	7870	6730	9120
20.000	94.00	20.000	508.00	J55	7830	10620	9070	12,290
20.000	106.50	20.000	508.00	J55	9130	12370	10,560	14,320
20.000	133.00	20.00	508.00	J55	11920	16160	13,790	18,700
20.000	94.00	20.000	508.00	K55	8230	11160	9550	12,950
20.000	106.50	20.000	508.00	K55	9590	13000	11,130	15,090
20.000	133.00	20.000	508.00	K55	12520	16980	14,530	19,700
20.000	94.00	20.000	508.00	M65	9180	12450	10,630	14,410
20.000	106.50	20.000	508.00	M65	10700	14510	12,380	16,790

Notes:
1. It is recommended that the makeup target be based on position, not torque. See 4.4.1 and 4.4.2.
2. Under normal circumstances, and for sizes $13^3/_8$ and smaller, variations in the listed torque values of ±25% should be considered acceptable.

the coupling replaced and tightened before pulling the tubing into the derrick.

f. Before stabbing, liberally apply thread compound to the entire internally and externally threaded areas. It is recommended that a thread compound that meets the performance objectives of API Bulletin 5A2 be used; however, in special cases where severe conditions are encountered, it is recommended that high-pressure silicone thread compound as specified in API Bulletin 5A2 be used.

g. Connectors used as tensile and lifting members should have their thread capacity carefully checked to ensure that the connector can safely support the load.

h. Care should be taken when making up pup joints and connectors to ensure that the mating threads are of the same size and type.

5.1.10 For high-pressure or condensate wells, additional precautions should be taken to ensure tight joints as follows:

a. Couplings should be removed, and both the mill-end pipe thread and coupling thread thoroughly cleaned and inspected. To facilitate this operation, tubing may be ordered with couplings handling tight, which is approximately one turn beyond hand tight, or may be ordered with the couplings shipped separately.

b. Thread compound should be applied to both the external and internal threads, and the coupling should be reapplied handling tight. Field-end threads and the mating coupling threads should have thread compound applied just before stabbing.

5.1.11 When tubing is pulled into the derrick, care should be taken that the tubing is not bent or couplings or protectors bumped.

5.2 STABBING, MAKING UP, AND LOWERING

5.2.1 Do not remove thread protector from field end of tubing until ready to stab.

5.2.2 If necessary, apply thread compound over entire surface of threads just before stabbing. The brush or utensil used in applying thread compound should be kept free of foreign matter, and the compound should never be thinned.

5.2.3 In stabbing, lower tubing carefully to avoid injuring threads. Stab vertically, preferably with the assistance of a man on the stabbing board. If the tubing tilts to one side after stabbing, lift up, clean, and correct any damaged thread with a three-cornered file, then carefully remove any filings and reapply compound over the thread surface. Care should be exercised, especially when running doubles or triples, to prevent bowing and resulting errors in alignment when the tubing is allowed to rest too heavily on the coupling threads. Intermediate supports may be placed in the derrick to limit bowing of the tubing.

Table 2—Torque Values for Extreme-Line Casing

Size, Outside Diameter (in.)	Torque, ft-lb J55 & K55	C75, L80, N80, C90	C95, P110	Q125
5	2700	3200	3700	4200
$5^{1}/_{2}$	2700	3200	3700	4200
$6^{5}/_{8}$	3200	3700	4200	4700
7	3200	3700	4200	4700
$7^{5}/_{8}$	3700	4200	4700	5200
$8^{5}/_{8}$	4200	4700	5200	5700
$9^{5}/_{8}$	4700	5200	6200	6700

Size, Outside Diameter (mm)	Torque, N • m J55 & K55	C75, L80, N80, C90	C95, P110	Q125
127.0	3660	4340	5020	5690
139.7	3660	4340	5020	5690
168.3	4340	5020	5690	6370
177.8	4340	5020	5690	6370
193.7	5020	5690	6370	7050
219.1	5690	6370	7050	7730
244.5	6780	7050	8410	9080

Notes:
1. The torque values listed above are recommended for use in conjunction with close visual examination to be sure the shoulder closes and to avoid excessive bos swelling.
2. The outside shoulder is not sealing surface; serves as a stop only.
3. Torque values higher than those listed above may be considered under certain conditions, providing box swelling does not occur.
4. Increased axial tension stress due to higher torque values could be excessive for sulfide service.
5. If the connection does not shoulder when maximum torque is applied, it should be treated as a questionable joint as provided under 4.4.3.
6. Recommended makeup torque values for size $10^{3}/_{4}$ are not available due to lack of data.

5.2.4 After stabbing, start screwing by hand or apply regular or power tubing tongs slowly. To prevent galling when making connections in the field, the connections should be made up at a speed not to exceed 25 rpm. Power tubing tongs are recommended for high-pressure or condensate wells to ensure uniform makeup and tight joints. Joints should be made up tight, approximately two turns beyond the hand-tight position, with care being taken not to gall the threads. When the additional preparation and inspection precautions for high-pressure or condensate wells are taken, the coupling will “float” or make up simultaneously at both ends until the proper number of turns beyond the hand-tight position have been obtained. The hand-tight position may be determined by checking several joints on the rack and noting the number of threads exposed when a coupling is made up with a torque of 50 ft-lb (68 N • m).

5.3 FIELD MAKEUP

5.3.1 Joint life of tubing under repeated field makeup is inversely proportional to the field makeup torque applied. Therefore, in wells where leak resistance is not a great factor, minimum field makeup torque values should be used to prolong joint life. The use of power tongs for making up tubing made desirable the establishment of recommended torque values for each size, weight, and grade of tubing. Table 3 contains makeup torque guidelines for nonupset, external upset, and integral joint tubing, based on 1 percent of the calculated joint pullout strength determined from the joint pullout strength formula for 8-round-thread casing in API Bulletin 5C3. All values are rounded to the nearest 10 ft-lb (13.5 N • m). The torque values listed in Table 3 apply to tubing with zinc-plated or phosphate-coated couplings. When making up connections with tin-plated couplings, 80 percent of the listed value can be used as a guide. When making up round-thread connections with PTFE (polytetrafluoroethylene) rings, 70 percent of the listed values are recommended. As with standard couplings, makeup positions shall govern. Buttress connections with PTFE seal rings may make up at torque values different from those normally observed on standard buttress threads.

Note: Thread galling of gall-prone materials (martensitic chromium steels, 9 Cr and 19 Cr) occurs during movement—stabbing or pulling and makeup or breakout. Galling resistance of threads is primarily controlled in two areas—surface preparation and finishing during manufacture and careful handling practices during running and pulling. Threads and lubricant must be clean. Assembly in the horizontal position should be avoided. Connections should be turned by hand to the hand-tight position before slowly power tightening. The procedure should be reversed for disassembly.

5.3.2 Spider slips and elevators should be cleaned frequently, and slips should be kept sharp.

5.3.3 Finding bottom should be accomplished with extreme caution. Do not set tubing down heavily.

5.4 PULLING TUBING

5.4.1 A caliper survey prior to pulling a worn string of tubing will provide a quick means of segregating badly worn lengths for removal.

5.4.2 Breakout tongs should be positioned close to the coupling. Hammering the coupling to break the joint is an injurious practice. When tapping is required, use the flat face, never the peen face, of the hammer, and tap lightly at the middle and completely around the coupling, never near the end or on opposite sides only.

5.4.3 Great care should be exercised to disengage all of the thread before lifting the tubing out of the coupling. Do not jump tubing out of the coupling.

5.4.4 Tubing stacked in the derrick should be set on a firm wooden platform and without the bottom thread protector since the design of most protectors is not such as to support the joint or stand without damage to the field thread.

5.4.5 Protect threads from dirt or injury when the tubing is out of the hole.

5.4.6 Tubing set back in the derrick should be properly supported to prevent undue bending. Tubing sizes $2^3/_8$ and larger preferably should be pulled in stands approximately 60 feet (18.3 meters) long or in doubles of range 2. Stands of tubing sizes 1.900 OD or smaller and stands longer than 60 feet (18.3 meters) should have intermediate support.

5.4.7 Before leaving a location, always firmly tie a setback of tubing in place.

5.4.8 Make sure threads are undamaged, clean, and well coated with compound before rerunning.

5.4.9 Distribute joint and tubing wear by moving a length from the top of the string to the bottom each time the tubing is pulled.

5.4.10 In order to avoid leaks, all joints should be retightened occasionally.

5.4.11 When tubing is stuck, the best practice is to use a calibrated weight indicator. Do not be misled, by stretching of the tubing string, into the assumption that the tubing is free.

5.4.12 After a hard pull to loosen a string of tubing, all joints pulled on should be retightened.

5.4.13 All threads should be cleaned and lubricated or should be coated with a material that will minimize corrosion. Clean protectors should be placed on the tubing before it is laid down.

5.4.14 Before tubing is stored or reused, pipe and threads should be inspected and defective joints marked for shopping and regauging.

5.4.15 When tubing is being retrieved because of a tubing failure, it is imperative to future prevention of such failures that a thorough metallurgical study be made. Every attempt should be made to retrieve the failed portion in the "as-failed" condition. When thorough metallurgical analysis reveals some facet of pipe quality to be involved in the failure, the results of the study should be reported to the API office.

5.5 CAUSES OF TUBING TROUBLES

The most common causes of tubing troubles are listed in 5.5.1 through 5.5.15.

5.5.1 Improper selection for strength and life required, especially of nonupset tubing where upset tubing should be used.

5.5.2 Insufficient inspection of finished product at the mill and in the yard.

5.5.3 Careless loading, unloading, and cartage.

5.5.4 Damaged threads resulting from protectors loosening and falling off.

5.5.5 Lack of care in storage to give proper protection.

5.5.6 Excessive hammering on couplings.

5.5.7 Use of worn-out and wrong types of handling equipment, spiders, tongs, dies, and pipe wrenches.

5.5.8 Nonobservance of proper rules in running and pulling tubing.

5.5.9 Coupling wear and rod cutting.

5.5.10 Excessive sucker rod breakage.

5.5.11 Fatigue, which often causes failure at the last engaged thread. There is no positive remedy, but using external upset tubing in place of nonupset tubing greatly delays the start of this trouble.

5.5.12 Replacement of worn couplings with non-API couplings.

5.5.13 Dropping a string, even a short distance. This may loosen the couplings at the bottom of the string. The string should be pulled and rerun, examining all joints very carefully.

5.5.14 Leaking joints, under external or internal pressure, are a common trouble, and may be due to the following:

a. Improper thread compound and/or improper application.
b. Dirty threads, or threads contaminated with coating material used as protection from corrosion.
c. Undertonging or overtonging.
d. Galled threads due to dirt, careless stabbing, damaged threads, and poor or diluted thread compound.
e. Improperly cut field threads.
f. Couplings that have been dented by hammering.
g. Pulling too hard on string.
h. Excessive rerunning.

5.5.15 Corrosion. Both the inside and outside of tubing can be damaged by corrosion. The damage is generally in the form of pitting, box wear, stress-corrosion cracking, and sulfide stress cracking; but localized attack like corrosion-erosion, ringworm, and caliper tracks can also occur. Pitting and wear by the sucker rod box can be determined visually by caliper surveys. Cracking may require aids, such as magnetic powder, for detection. Corrosion products may or may not adhere to the pipe walls. Corrosion is generally due to the corrosive well fluid but may be aggravated by the abrasive effects of pumping equipment, by gas lifting, or by high velocities. Corrosion can also be influenced by dissimilar metals in close proximity to each other (bimetallic corrosion) and by variations in grain structure, surface conditions, and deposits (concentration cell corrosion). Since corrosion may result from many causes and influences and take different forms, no simple or universal remedy can be given for control. Each problem shall be treated individually, and the solution shall be attempted in light of known factors and operating conditions.

5.5.15.1 Where internal or external tubing corrosion is known to exist and corrosive fluids are being produced, the following measures can be employed:

a. In flowing wells, the annulus can be packed off and the corrosive fluid confined to the inside of the tubing. The inside of tubing can be protected with special liners, coatings, or inhibitors. Under severe conditions, special alloy steel or glass reinforced plastics may be used. Alloys do not always eliminate corrosion. When H_2S is present in the well fluids, tubing of high yield strength may be subject to sulfide corrosion cracking. The concentration of H_2S necessary to cause cracking in different strength materials is not yet well defined. Literature on sulfide corrosion or persons competent in this field should be consulted.
b. In pumping and gas-lift wells, inhibitors introduced via the casing-tubing annulus afford appreciable protection. In this type of completion, especially in pumping wells, better operating practices can also aid in extending the life of tubing, such as through the use of rod protectors, rotation of tubing, and longer and slower pumping strokes.

5.5.15.2 To determine the value and effectiveness of the above practices and measures, cost and equipment failure records can be compared before and after application of control measures. Inhibitor effectiveness can also be checked by means of coupons, caliper surveys, and visual examinations of readily accessible pieces of equipment. Water analyses to determine the iron content before and after starting the inhibitor treatment may also serve as an indication of the comparative rates of corrosion. When lacking previous experience with any of the above measures, these should be used cautiously and on a limited scale until appraised for the particular operating conditions.

5.5.15.3 In general, all new areas should be considered as being potentially corrosive, and investigations should be initiated early in the life of a field, and repeated periodically, to detect and localize corrosion before it has done destructive damage. These investigations should cover the following:

a. An analysis of produced gas for carbon dioxide and hydrogen sulfide. Also desirable is an analysis of the effluent water for pH, iron content, organic acids, total chlorides, and other substances believed to influence the individual problem.
b. Corrosion rate tests by using coupons of the same materials as in the well.
c. The use of caliper or optical-instrument inspections.

Where conditions favorable to corrosion exist, a qualified corrosion engineer should be consulted. Particular attention should be given to mitigation of corrosion where the probable life of subsurface equipment is less than the time expected to deplete a well.

6 Transportation, Handling, and Storage

API tubular goods in general, and threads in particular, are made with such precision that they require careful handling, and whether new, used, or reconditioned, they should always be handled with thread protectors in place.

6.1 TRANSPORTATION

6.1.1 Water Transportation

Pipe suppliers or their agents should provide proper supervision at the time of loading and unloading of water carriers to guard against improper or insufficient dunnage, inadequate bracing to prevent shifting during lurching of the ship, stowing pipe in or adjacent to bilge water, injurious chemicals or other corrosive material, dragging pipe along the pile and permitting couplings or thread protectors to hook together or strike the edge of a hatch opening or bump against the ship rail.

6.1.2 Railroad Transportation

When loading pipe on freight cars, in addition to Interstate Commerce Commission requirements, wooden stringers should be provided across the bottom of the car to provide suitable support for pipe, to allow space for lifting, and to keep pipe away from dirt. If the bottom of the car is uneven, the stringers should be rigidly shimmed so that their tops will be in the same plane. Stringers should not be placed under couplings or the upset part of pipe. The load should be tied down and properly bulkheaded to keep it from shifting.

6.1.3 Truck Transportation

The following precautions should be taken for truck transportation:

a. Load pipe on bolsters and tie down with suitable chain at the bolsters. In hauling long pipe, an additional chain should be provided in the middle.

b. Load pipe with all couplings on the same end of the truck.

c. Care should be taken to prevent chafing of tool-joint shoulders on adjacent joints.

d. Do not overload truck to the point where there is any danger that the load cannot be delivered to its destination without unloading.

e. After the load has been hauled a short distance, retighten load-binding chains loosened as a result of the load settling.

6.2 HANDLING

The following precautions should be observed when handling casing and tubing:

a. Before loading or unloading make sure that the thread protectors are tightly in place. Do not unload pipe by dropping. Avoid rough handling which might damage the threads or ding or dent the body of the pipe. Damaged threads may leak or part. Dents and out-of-roundness may reduce the collapse resistance of the pipe.

Special handling may be required for sour service and CRA material. Impact against adjacent pipe or other objects may cause a local increase in the hardness of the pipe to the extent that they become susceptible to sulfide stress cracking. The owner of pipe which requires special handling requirements should notify his service providers of the applicable special handling requirements and to which pipe the special requirements are applicable.

b. When unloading by hand, use rope slings to control the pipe. When rolling down skids, roll pipe parallel to the stack and do not allow pipe to gather momentum or to strike the ends, because even with thread protectors in place there is danger of damaging the threads.

c. When using a crane, the use of spreader-bar with a choker-sling(s) at each end is the recommended method of handling long pipe. Each choker-sling shall be double wrapped.

d. When rolling pipe, on the rack, keep pipe parallel and do not allow pipe to gather momentum or to strike the ends.

6.3 STORAGE

The following precautions are recommended for pipe storage:

a. Do not pile pipe directly on ground, rails, and steel or concrete floors. The first tier of pipe should be no less than 18 inches (500 millimeters) from the ground to keep moisture and dirt away from pipe.

b. Pipe should rest on supports properly spaced to prevent bending of the pipe or damage to the threads. The stringers should lie in the same plane and be reasonably level and should be supported by piers adequate to carry the full stack load without settling.

c. Provide wooden strips as separators between successive layers of pipe so that no weight rests on the couplings. Use at least three spacing strips.

d. Place spacing strips at right angles to pipe and directly above the lower strips and supports to prevent bending of pipe.

e. Stagger adjoining lengths of pipe in the tiers an amount approximating the length of the coupling.

f. Block pipe by nailing 1 by 2 or 2 by 2 blocks at both ends of the spacing strips.

g. For purposes of safety, ease of inspection, and handling, pipe should not be stacked higher than 10 feet (3000 millimeters). Pipe should not be stacked higher than five tiers at the rig.

h. Pipe in storage should be inspected periodically and protective coatings applied when necessary to arrest corrosion.

7 Inspection and Classification of Used Casing and Tubing

Inspection standards and classification for used casing and tubing have been established and the procedures are outlined in this section.

7.1 INSPECTION AND CLASSIFICATION PROCEDURES

7.1.1 Inspection Capability

Presently accepted methods of inspecting the body section of pipe are visual, mechanical gauging, electromagnetic, eddy current, ultrasonic, and gamma ray. These inspection techniques are limited to location of cracks, pits, and other surface imperfections. Service induced defects considered to be representative of defects associated with used pipe inspection are as follows: outside and inside corrosion damage; inside surface wireline (longitudinal) damage; outside transverse and longitudinal slip and tong cuts; inside surface drill pipe wear (casing only); transverse cracking (work tubing only); and inside surface sucker rod wear (tubing only).

7.1.2 Measurement of Pipe Wall (Minimum Wall)

The only acceptable wall thickness measurements are those made with pipe wall micrometers, sonic pulse-echo

Table 3—Tubing Makeup Torque Guidelines—Round Thread Tubing

(1)		(2)	(3)	(4)	(5)	
Size, Outside Diameter		Nominal Weight, Threads and Coupling			Torque	
in.	mm	(lb/ft)	Grade	Thread	ft-lb	N • m
1.050	26.7	1.14	H40	NU	140	190
1.050	26.7	1.14	J55	NU	180	240
1.050	26.7	1.14	C75	NU	230	320
1.050	26.7	1.14	L80	NU	240	330
1.050	26.7	1.14	N80	NU	250	340
1.050	26.7	1.14	C90	NU	260	350
1.050	26.7	1.20	H40	EUE	460	630
1.050	26.7	1.20	J55	EUE	600	810
1.050	26.7	1.20	C75	EUE	780	1060
1.050	26.7	1.20	L80	EUE	810	1090
1.050	26.7	1.20	N80	EUE	830	1130
1.050	26.7	1.20	C90	EUE	880	1190
1.315	33.4	1.70	H40	NU	210	280
1.315	33.4	1.70	J55	NU	270	370
1.315	33.4	1.70	C75	NU	360	480
1.315	33.4	1.70	L80	NU	370	500
1.315	33.4	1.70	N80	NU	380	510
1.315	33.4	1.70	C90	NU	400	540
1.315	33.4	1.80	H40	EUE	440	590
1.315	33.4	1.80	J55	EUE	570	770
1.315	33.4	1.80	C75	EUE	740	1010
1.315	33.4	1.80	L80	EUE	760	1040
1.315	33.4	1.80	N80	EUE	790	1070
1.315	33.4	1.80	C90	EUE	830	1130
1.315	33.4	1.72	H40	IJ	310	410
1.315	33.4	1.72	J55	IJ	400	540
1.315	33.4	1.72	C75	IJ	520	700
1.315	33.4	1.72	L80	IJ	530	720
1.315	33.4	1.72	N80	IJ	550	740
1.315	33.4	1.72	C90	IJ	580	780
1.660	42.2	2.30	H40	NU	270	360
1.660	42.2	2.30	J55	NU	350	470
1.660	42.2	2.30	C75	NU	460	620
1.660	42.2	2.30	L80	NU	470	640
1.660	42.2	2.30	N80	NU	490	660
1.660	42.2	2.30	C90	NU	510	700
1.660	42.2	2.30	H40	EUE	530	720
1.660	42.2	2.40	J55	EUE	690	940
1.660	42.2	2.40	C75	EUE	910	1230
1.660	42.2	2.40	L80	EUE	940	1270
1.660	42.2	2.40	N80	EUE	960	1300
1.660	42.2	2.40	C90	EUE	1020	1380

Table 3—Tubing Makeup Torque Guidelines—Round Thread Tubing (Continued)

(1)		(2)	(3)	(4)	(5)	
Size, Outside Diameter		Nominal Weight, Threads and Coupling			Torque	
in.	mm	(lb/ft)	Grade	Thread	ft-lb	N • m
1.660	42.2	2.10	H40	IJ	380	520
1.660	42.2	2.33	H40	IJ	380	520
1.660	42.2	2.10	J55	IJ	500	680
1.660	42.2	2.33	J55	IJ	500	680
1.660	42.2	2.33	C75	IJ	650	890
1.660	42.2	2.33	L80	IJ	680	920
1.660	42.2	2.33	N80	IJ	690	940
1.660	42.2	2.33	C90	IJ	730	1000
1.900	48.3	2.75	H40	NU	320	430
1.900	48.3	2.75	J55	NU	410	560
1.900	48.3	2.75	C75	NU	540	730
1.900	48.3	2.75	L80	NU	560	760
1.900	48.3	2.75	N80	NU	570	780
1.900	48.3	2.75	C90	NU	610	830
1.900	48.3	2.90	H40	EUE	670	910
1.900	48.3	2.90	J55	EUE	880	1190
1.900	48.3	2.90	C75	EUE	1150	1560
1.900	48.3	2.90	L80	EUE	1190	1610
1.900	48.3	2.90	N80	EUE	1220	1650
1.900	48.3	2.90	C90	EUE	1300	1760
1.900	48.3	2.40	H40	IJ	450	600
1.900	48.3	2.76	H40	IJ	450	600
1.900	48.3	2.40	J55	IJ	580	790
1.900	48.3	2.76	J55	IJ	580	790
1.900	48.3	2.76	C75	IJ	760	1030
1.900	48.3	2.76	L80	IJ	790	1070
1.900	48.3	2.76	N80	IJ	810	1100
1.900	48.3	2.76	C90	IJ	860	1160
2.063	52.4	3.25	H40	IJ	570	770
2.063	52.4	3.25	J55	IJ	740	1010
2.063	52.4	3.25	C75	IJ	970	1320
2.063	52.4	3.25	L80	IJ	1010	1370
2.063	52.4	3.25	N80	IJ	1030	1400
2.063	52.4	3.25	C90	IJ	1100	1490
2.375	60.3	4.00	H40	NU	470	630
2.375	60.3	4.60	H40	NU	560	760
2.375	60.3	4.00	J55	NU	610	830
2.375	60.3	4.60	J55	NU	730	990
2.375	60.3	4.00	C75	NU	800	1090
2.375	60.3	4.60	C75	NU	960	1300
2.375	60.3	5.80	C75	NU	1380	1860
2.375	60.3	4.00	L80	NU	830	1130
2.375	60.3	4.60	L80	NU	990	1350
2.375	60.3	5.80	L80	NU	1420	1930

Table 3—Tubing Makeup Torque Guidelines—Round Thread Tubing (Continued)

(1)		(2)	(3)	(4)	(5)	
Size, Outside Diameter		Nominal Weight, Threads and Coupling			Torque	
in.	mm	(lb/ft)	Grade	Thread	ft-lb	N • m
2.375	60.3	4.00	N80	NU	850	1160
2.375	60.3	4.60	N80	NU	1020	1380
2.375	60.3	5.80	N80	NU	1460	1980
2.375	60.3	4.00	C90	NU	910	1230
2.375	60.3	4.60	C90	NU	1080	1470
2.375	60.3	5.80	C90	NU	1550	2110
2.375	60.3	4.60	P105	NU	1280	1740
2.375	60.3	5.80	P105	NU	1840	2490
2.375	60.3	4.70	H40	EUE	990	1340
2.375	60.3	4.70	J55	EUE	1290	1750
2.375	60.3	4.70	C75	EUE	1700	2310
2.375	60.3	5.95	C75	EUE	2120	2870
2.375	60.3	4.70	L80	EUE	1760	2390
2.375	60.3	5.95	L80	EUE	2190	2970
2.375	60.3	4.70	N80	EUE	1800	2450
2.375	60.3	5.95	N80	EUE	2240	3040
2.375	60.3	4.70	C90	EUE	1920	2610
2.375	60.3	5.95	C90	EUE	2390	3250
2.375	60.3	4.70	P105	EUE	2270	3080
2.375	60.3	5.95	P105	EUE	2830	3830
2.875	73.0	6.40	H40	NU	900	1080
2.875	73.0	6.40	J55	NU	1050	1420
2.875	73.0	6.40	C75	NU	1380	1880
2.875	73.0	7.80	C75	NU	1850	2500
2.875	73.0	8.60	C75	NU	2090	2830
2.875	73.0	6.40	L80	NU	1430	1940
2.875	73.0	7.80	L80	NU	1910	2590
2.875	73.0	8.60	L80	NU	2160	2930
2.875	73.0	6.40	N80	NU	1470	1990
2.875	73.0	7.80	N80	NU	1960	2650
2.875	73.0	8.60	N80	NU	2210	3000
2.875	73.0	6.40	C90	NU	1570	2130
2.875	73.0	7.80	C90	NU	2090	2840
2.875	73.0	8.60	C90	NU	2370	3210
2.875	73.0	6.40	P105	NU	1850	2510
2.875	73.0	7.80	P105	NU	2470	3350
2.875	73.0	8.60	P105	NU	2790	3790
2.875	73.0	6.50	H40	EUE	1250	1700
2.875	73.0	6.50	J55	EUE	1650	2230
2.875	73.0	6.50	C75	EUE	2170	2940
2.875	73.0	7.90	C75	EUE	2610	3540
2.875	73.0	8.70	C75	EUE	2850	3860
2.875	73.0	6.50	L80	EUE	2250	3050
2.875	73.0	7.90	L80	EUE	2710	3680
2.875	73.0	8.70	L80	EUE	2950	4000
2.875	73.0	6.50	N80	EUE	2300	3120

Table 3—Tubing Makeup Torque Guidelines—Round Thread Tubing (Continued)

(1)		(2)	(3)	(4)	(5)	
Size, Outside Diameter		Nominal Weight, Threads and Coupling			Torque	
in.	mm	(lb/ft)	Grade	Thread	ft-lb	N • m
2.875	73.0	7.90	N80	EUE	2770	3760
2.875	73.0	8.70	N80	EUE	3020	4090
2.875	73.0	6.50	C90	EUE	2460	3340
2.875	73.0	7.90	C90	EUE	2970	4020
2.875	73.0	8.70	C90	EUE	3230	4380
2.875	73.0	6.50	P105	EUE	2910	3940
2.875	73.0	7.90	P105	EUE	3500	4750
2.875	73.0	8.70	P105	EUE	3810	5170
3.500	88.9	7.70	H40	NU	920	1250
3.500	88.9	9.20	H40	NU	1120	1520
3.500	88.9	10.20	H40	NU	1310	1770
3.500	88.9	7.70	J55	NU	1210	1640
3.500	88.9	9.20	J55	NU	1480	2010
3.500	88.9	10.20	J55	NU	1720	2330
3.500	88.9	7.70	C75	NU	1600	2170
3.500	88.9	9.20	C75	NU	1950	2650
3.500	88.9	10.20	C75	NU	2270	3080
3.500	88.9	12.70	C75	NU	3030	4100
3.500	88.9	7.70	L80	NU	1660	2250
3.500	88.9	9.20	L80	NU	2030	2750
3.500	88.9	10.20	L80	NU	2360	3200
3.500	88.9	12.70	L80	NU	3140	4260
3.500	88.9	7.70	N80	NU	1700	2300
3.500	88.9	9.20	N80	NU	2070	2810
3.500	88.9	10.20	N80	NU	2410	3270
3.500	88.9	12.70	N80	NU	3210	4350
3.500	88.9	7.70	C90	NU	1820	2460
3.500	88.9	9.20	C90	NU	2220	3010
3.500	88.9	10.20	C90	NU	2590	3510
3.500	88.9	12.70	C90	NU	3440	4670
3.500	88.9	9.20	P105	NU	2620	3550
3.500	88.9	12.70	P105	NU	4060	5510
3.500	88.9	9.30	H40	EUE	1730	2340
3.500	88.9	9.30	J55	EUE	2280	3090
3.500	88.9	9.30	C75	EUE	3010	4080
3.500	88.9	12.95	C75	EUE	4040	5480
3.500	88.9	9.30	L80	EUE	3030	4240
3.500	88.9	12.95	L80	EUE	4200	5700
3.500	88.9	9.30	N80	EUE	3200	4330
3.500	88.9	12.95	N80	EUE	4290	5820
3.500	88.9	9.30	C90	EUE	3430	4650
3.500	88.9	12.95	C90	EUE	4610	6250
3.500	88.9	9.30	P105	EUE	4050	5490
3.500	88.9	12.95	P105	EUE	5430	7370
4.000	101.6	9.50	H40	NU	930	1260
4.000	101.6	9.50	J55	NU	1220	1660

Table 3—Tubing Makeup Torque Guidelines—Round Thread Tubing (Continued)

(1)		(2)	(3)	(4)	(5)	
Size, Outside Diameter		Nominal Weight, Threads and Coupling			Torque	
in.	mm	(lb/ft)	Grade	Thread	ft-lb	N • m
4.000	101.6	9.50	C75	NU	1620	2200
4.000	101.6	9.50	L80	NU	1680	2280
4.000	101.6	9.50	N80	NU	1720	2330
4.000	101.6	9.50	C90	NU	1950	2500
4.000	101.6	11.00	H40	EUE	1940	2630
4.000	101.6	11.00	J55	EUE	2560	3470
4.000	101.6	11.00	C75	EUE	3390	4600
4.000	101.6	11.00	L80	EUE	3530	4780
4.000	101.6	11.00	N80	EUE	3600	4880
4.000	101.6	11.00	C90	EUE	3870	5250
4.500	114.3	12.60	H40	NU	1320	1780
4.500	114.3	12.60	J55	NU	1740	2360
4.500	114.3	12.60	C75	NU	2300	3120
4.500	114.3	12.60	L80	NU	2400	3250
4.500	114.3	12.60	N80	NU	2440	3310
4.500	114.3	12.60	C90	NU	2630	3570
4.500	114.3	12.75	H40	EUE	2160	2930
4.500	114.3	12.75	J55	EUE	2860	3870
4.500	114.3	12.75	C75	EUE	3780	5130
4.500	114.3	12.75	L80	EUE	3940	5340
4.500	114.3	12.75	N80	EUE	4020	5450
4.500	114.3	12.75	C90	EUE	4330	5870

Notes:
1. It is recommended that the makeup target be based on position, not torque. See 5.2.4 and 5.3.1.
2. Under normal circumstances, variations in the listed torque values of ± 25 % should be considered acceptable.

instruments, or gamma-ray devices that the operator can demonstrate to be within 2 percent accuracy by use of test blocks sized to approximate pipe wall thickness.

7.1.3 Procedure

Used casing and tubing should be classified according to the loss of nominal wall thickness listed in Table 4.

These percentages represent reductions in the body wall from the API specified pipe wall thickness. This loss of wall thickness affects the body areas along both the inside and/or outside surfaces. Pipe with loss of wall thickness in the threaded portion and/or upset section, whether threaded and coupled external upset or integral joint, is not to be classified in accordance with Table 4. Loss of wall thickness in the heavier upset sections could be permitted to a higher percentage without penalty depending on the intended service. Damages and/or wall reductions affecting the threaded ends of pipe require individual consideration depending on the anticipated service by the owner of the pipe.

In addition to the body wall loss classification shown in Table 4, the color code identification system used to denote the conditions is provided in Table 5. The color coding should consist of a paint band of the appropriate color approximately 2 inches wide around the body of the pipe approximately 1 foot from the box end.

Table 4—Classification and Color Coding of Used Casing and Tubing

(1)	(2)	(3)	(4)
Class	Color Band	Loss of Nomnal Wall Thickness (percent)	Remaining Wall Thickness (percent minimum)
2	Yellow	0 – 15	85
3	Blue	16 – 30	70
4	Green	31 – 50	50
5	Red	Over 50	less than 50

Table 5—Color Code Identification

Conditions	Color
Damaged field- or pin-end threads	One red paint band approximately 2 inches wide around the affected coupling or box end.
Damaged coupling or box connections	One red paint band approximately 2 inches wide around the pipe adjacent to affected threads.
Pipe body will not pass drift test	One green paint band approximately 2 inches wide at the point of drift restriction and adjacent to the color band denoting body wall classification.

7.1.4 Performance Properties

Performance properties of new casing, tubing, and drill pipe are usually based on equations in API Bulletin 5C3. However, there is no standard method for calculating performance properties of used casing and tubing. API Recommended Practice 7G provides a recommended practice for calculating performance properties of used drill pipe. Drill pipe wear usually occurs on the outside surface and, consequently, the performance properties of used drill pipe are based on a constant ID, and the wall thickness and OD vary with the degree of wear.

Casing and tubing wear (metal loss) and corrosion usually occur on the inside surface. Performance properties should be based on a constant OD. If external corrosion is evident, it must also be taken into account. Small pits or other localized metal loss may not be damaging depending on the application of the pipe, but this type of metal loss should be considered and evaluated by the pipe owner.

If cracks are detected in a length of pipe during inspection and are verified to be of sufficient length to be identified by either visual, optical, or magnetic particle inspection, this joint shall be rejected and considered unfit for further service.

7.2 GENERAL

The following general comments concern loss of pipe wall thickness and conditions of the threaded joint.

7.2.1 Pipe Wall

Metal losses in used casing and tubing usually occur on the inside surface and range in character from isolated pits, gouges, or cuts to massive reductions caused by mechanical wear or sand cutting. Wear occurs inside casing and liners by rotation and movement of the drill string while drilling. Wear occurs inside the casing even though rubber protectors are applied to the drill pipe. The amount of wear increases with the length of time the casing is drilled through. Frequently, wear occurs on only one side, that being the casing on the low side of the hole. The performance properties can be calculated by using the remaining wall thickness. Some experience has shown that wire-line wear has a greater effect than drill pipe wear on burst rating, and it has been suggested that burst pressures be reduced if wall reduction is caused by wire-line wear.

The type of metal loss may influence the application of used casing and tubing. Pipe with pits may not be used under some corrosive conditions but may perform satisfactorily where corrosion is not a factor. Pipe having more uniform metal loss from mechanical wear should be less vulnerable to corrosive conditions and needs only to be derated for the minimum remaining wall thickness.

7.2.2 Threads

When inspecting threads of used casing and tubing, one should check for the following: pulled round threads, galling, and fatigue cracks in the last engaged thread. A fast thread lead at the area of last thread engagement of round threads would indicate that the threads became stretched when pulled at loads exceeding the yield strength of the connection. They may make into a coupling on the next makeup but would not have the anticipated joint strength and could have inadequate leak resistance. Galling is always a possibility that may be encountered while breaking out connections, particularly when backups are placed on the coupling. Also on repeated makeup, the threads make up more each time and interference occurs. Work tubing and strings subjected to reciprocal tension stress often develop fatigue cracks at the root of the last engaged thread that could reduce tension values or propagate to joint failure during further use. These situations would require shopping of the threads to restore the length to usable status. It should not be expected that threaded connections shall gauge properly after being made up power tight, therefore minor deviations from the specified tolerances should be accepted.

7.2.3 Pin Cone Reduction

Tubing that has made multiple round-trips in the hole, as in the case of work strings, may have pins reduced in diameter due to successive yielding by repeated makeups. This condition may penalize joint strength, leak resistance, and in severe cases, lead to abutment of pin ends near the center of the coupling in the made-up connection.

7.3 SERVICE RATING

Final rating of a length of pipe for further services requires consideration of the ID wall condition and remaining wall thickness to evaluate resistance of the body to collapse, burst, and tension; consideration of the thread condition to evaluate resistance to leaks; and consideration of the pin cone to evaluate makeup.

Depending on circumstances and emergency needs, gauging of the threads may be considered along with the usual wall inspection to determine final performance properties.

Utilization of the used casing or tubing should be based on experience and judgment with respect to well conditions and environmental factors.

8 Reconditioning

Tubular goods that have become damaged through use or abuse may often be reconditioned to advantage. This should be done only in accordance with API Specification 5CT. The acceptability of reconditioned threads should always be confirmed by gauging and inspection in accordance with API Specification 5B.

9 Field Welding of Attachments on Casing

9.1 INTRODUCTION

9.1.1 The selection of steel for use in casing is governed by important considerations dictated by the service casing must perform. Steels most suitable for field welding do not have these performance properties. Therefore, field weldability shall not be of primary consideration in the selection of steel for the manufacture of casing. As a result, unless precautions are taken welding may have adverse effects on many of the steels used in all grades of casing, especially J55 and higher.

9.1.2 The heat from welding may affect the mechanical properties of high-strength casing steels. Cracks and brittle areas are likely to develop in the heat-affected zone. Hard areas or cracks may cause failure, especially when the casing is subjected to tool-joint battering. For these reasons, welding on high-strength casing should be avoided if possible.

9.1.3 Practices and equipment that shall eliminate welding are recommended. For example, cements or locking attachments might be used rather than welding bottom joints to prevent them from unscrewing. Similarly, use of mechanical means for attachment of centralizers and scratchers is encouraged.

9.1.4 Although welding on high-strength casing is not recommended as the best practice, it is recognized that under certain circumstances the user may elect to do so. In such cases, there are certain practices that, if followed, will minimize the deleterious effects of welding. The intent here is to outline practices that will serve as a guide to field personnel.

9.1.5 Welding is not recommended on those critical portions of the casing string where tension, burst, or collapse-strength properties shall not be impaired. If welding is necessary, it should be restricted to the lowermost portions of the cemented interval at the bottom of the casing string. Shoe-joint welding of couplings, when necessary, shall be used with extreme caution and with full use of procedures outlined herein.

9.1.6 The responsibility for welding lies with the user, and results are largely governed by the welder's skill. Weldability of the various types and grades of casing varies widely, thus placing added responsibility on the welder. Transporting a qualified welder to the job rather than using a less-skilled man who may be at hand will in most cases prove economical. The responsible operating representative should ascertain the welder's qualifications and, if necessary, assure himself by instruction or demonstration that the welder is able to perform the work satisfactorily.

9.2 REQUIREMENTS OF WELDS

9.2.1 Welds should have sufficient mechanical strength to prevent joints from backing off or to hold various attachments to the casing. In-service welds are called upon to withstand impact, pounding, vibration, and other severe service conditions to which casing is subjected. Ability to withstand bending forces is also often important. To accomplish this, ductile welds free from cracks and brittle or hard spots are desired.

9.2.2 Leak resistance is not a factor in welds covered by procedures herein outlined. The purpose of the welds is to make attachments or to prevent joints from unscrewing. Where welding is done on joints, the weld shall not be intended as a seal to prevent leakage but rather as a means of preventing the joint from backing off. Leak resistance is obtained by the joint itself.

9.2.3 Leak resistance is required for the seal weld in casing hangers.

9.3 PROCESS

Welding is currently being done by the metal-arc or oxyacetylene processes. Brazing alloys melting at 1200°F (650°C) or lower, which possess good mechanical properties, are available for application by the oxyacetylene or oxypropane torch. They may be used to avoid brittle areas or cracks that may occur in alloy casing when welded; but when so subjected to this temperature, a reduction in strength may result.

9.4 FILLER FOR ARC WELDING

When using the metal arc process, low-hydrogen electrodes should be used. These include all electrodes with the AWS classifications Exx 15, Exx 16, and Exx 18 in AWS Specification A5.1, *Covered Carbon Steel Arc Welding Electrodes*. Low-hydrogen electrodes should not be exposed to the atmosphere until ready for use. Electrodes must be stored in holding ovens at 150°F to 300°F (65°C to 150°C) immediately after their containers have been opened. Once removed from the holding oven, electrodes must be used within 30 minutes. Electrodes not used within this time limit must be discarded or reconditioned by baking at 600°F to 700°F

(315°C to 370°C) for 1 hour. After reconditioning, electrodes must be placed into the holding oven.

9.5 PREPARATION OF BASE METAL

The area to be welded should be dry and brushed or wiped free of any excess paint, grease, scale, rust, or dirt.

9.6 PREHEATING AND COOLING

9.6.1 Preheating is considered essential for welding all grades of casing. At least 3 inches (75 millimeters) on each side of weld locations should be preheated to 400°F to 600°F (205°C to 315°C). Preheat temperature should be maintained during welding. (Use a "Tempilstik" or equivalent temperature sensitive crayon to check temperature.)

9.6.2 Rapid cooling shall be avoided. To ensure slow cooling, welds should be protected from extreme weather conditions (cold, rain, high winds, etc.). Welds made on the casing as it is being run should be cooled in air to below 250°F (121°C) (measured with a "Tempilstik" or equivalent) prior to lowering the weld into the hole. The required cooling usually takes about 5 minutes.

9.7 WELDING TECHNIQUE

9.7.1 The weld should be started as soon as the specified preheat temperature has been attained. The welding operation should be shielded from strong winds, blowing dust and sand, and rain.

9.7.2 Where metal-arc welding is used, electrodes $^{3}/_{16}$-inch (4.8-millimeter) diameter or smaller should be used. Two pass welds are preferred, provided the second pass may be controlled so that it shall overlay only the weld metal and not extend to the casing. The function of the second pass is to temper or anneal the underlying weld and adjacent metal. This purpose is defeated if the second pass extends onto the casing. The second pass should be laid on very quickly after cleaning the first bead so as to prevent the metal heated by the first pass from cooling quickly enough to become brittle. Weaving should be kept to a minimum, and the current should be on the low side of the range recommended by the electrode manufacturer. Every effort should be made to avoid undercutting.

9.7.3 All slag or flux remaining on any welding bead should be removed by chipping or grinding before depositing the next bead.

9.7.4 Attachments should fit as closely as possible to the casing surface.

9.7.5 The arc shall not be struck on the casing, as every arc burn results in a hard spot and damage to the casing. Cracks have frequently resulted from striking the arc on casing. The arc should be struck on the attachment, which is made from steel not as susceptible to damage. If necessary to strike the arc on the casing, it should be struck in the area to be welded.

9.7.6 Care should be taken to ensure that the welding cable is properly grounded to the casing, but ground wire should not be welded to the casing. Ground wire should be firmly clamped to the casing or fixed in position between pipe slips. Bad contact may cause sparking, with resultant hard spots beneath which incipient cracks may develop. The welding cable should not be grounded to steel derrick, rotary-table base, or casing rack.

9.7.7 As much welding as possible should be done on the rack instead of on the rig floor or while the casing is hanging in the well. This procedure has the two-fold advantage of (a) welding under more favorable conditions, and (b) the weld cooling rate can be slower and more closely controlled. Do not ground to the rack but firmly clamp to casing being welded.

9.7.8 If couplings, float collars, and guide shoes are welded, sufficient metal should be deposited to prevent them from backing out. If the top side of the float collar and casing collars are welded while the casing is in the rotary or if the practice is not to make a complete weld, three 3-inch (75-millimeter) welds should be placed at 120-degree intervals around size $9^{5}/_{8}$ casing; three 4-inch (100-millimeter) welds should be placed on larger casing; and three 2-inch (50-millimeter) welds on smaller casing.

9.7.9 If welds longer than 4 inches (100 millimeters) to 6 inches (150 millimeters) are made, backstepping is advantageous. For example, if 6 inches (150 millimeters) of weld have been deposited as a stringer bead from left to right, then the operator should start about 6 inches (150 millimeters) to the left of the weld deposited and weld up to the starting point of the previously deposited weld.

9.7.10 Complete fillet welds should have approximately equal leg dimensions. Care should be taken to avoid undercutting. Two passes are preferred. (Welds should be cleaned between passes.)

9.7.11 When lugs are welded to casing, the weld should extend around the lug ends. It is good practice to strike the arc near the lug end, weld the end, and bring the weld back to about the lug center. The arc is momentarily broken so that the lug can be cut or burnt to length and the unwelded end hammered down against the casing. The weld is then continued around the second end, bringing the arc back on the weld before breaking. In this manner, ends are welded without either striking or breaking the arc at the ends.

9.7.12 When centralizers and scratchers are welded to casing, welds should be a minimum length of 2 inches (50 millimeters) at 2-inch (50-millimeter) intervals.

9.7.13 When rotating scratchers are welded to casing, full-length welds on each end, with $^{3}/_{4}$-inch (19-millimeter) welds at two equal spacings on the front edge and one $^{3}/_{4}$-inch (19-millimeter) weld on the center of the rear or trailing edge, have been found satisfactory.

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