

Technical Report on Material Toughness

API 6AM
SECOND EDITION, SEPTEMBER 1, 1995
(FORMERLY BULLETIN 6AM)

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005



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FOREWORD

This technical report is under the jurisdiction of the API Subcommittee on Valves and Wellhead Equipment. It is a report of the methodology and conclusions of a task group study of material toughness requirements for equipment covered by API Specification 6A, *Specification for Wellhead and Christmas Tree Equipment*. The report was first issued as API Bulletin 6AM, First Edition, September 1, 1989, and was reaffirmed and reissued in 1995 as a technical report designated API 6 AM.

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SUMMARY

CVN toughness requirements can be used as a quality assurance measure in API Specification 6A equipment to screen materials with poor notch toughness. This should help to minimize brittle fracture of wellhead and of christmas tree equipment in the field.

A minimum average of 15 ft-lb is justified in API Specification 6A for all temperature classifications of all PSL levels of equipment. This does not preclude the use of the current lateral expansion requirements for PSL level 4 equipment. The Task Group recommends 20 ft-lb. This compromise required that the Task Group stipulate 15 ft-lb in the *transverse direction*: in order to satisfy logic that required 15 ft-lb in the transverse direction, a longitudinal “equivalent” was necessary.

Additional work is required to establish brittle fracture criterion for API Specification 6A materials using Charpy-fracture mechanics correlations.

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1 Scope

1.1 INITIAL TASK GROUP CHARGE

The July 30, 1986, API Subcommittee Meeting Minutes contained the Material Toughness Task Group Charge. It comprised Attachment 6. The charge(s) were:

1. Evaluate the material toughness requirements for API Specification 6A materials, for acceptance worldwide.
2. Perform a survey of the industry and review literature for material toughness values based on technical data and design requirements.
3. Devise a method or action to resolve difference between the European and U.S. opinions on material toughness.
4. Establish work groups to prepare appropriate revisions to API Specification 6A for ballot by June 1987.

1.2 AMENDED TASK GROUP CHARGE

The Task Group came to several conclusions based on the charges:

Charge 1: The Task Group could not evaluate worldwide parameters necessary for acceptance of API Specification 6A materials toughness requirements. The justification for other groups' requirements was not readily obvious.

Charge 2: The members of the Task Group comprised a cross section of industry users and manufacturers which have worldwide exposure. The Task Group could not document any materials related failures on equipment whose materials had met the API Specification 6A requirement of 15 ft-lb. All documentable failures did not meet the existing requirements. A literature survey revealed no technical data or design requirements which are relatable to API Specification 6A equipment design or usage.

Charge 3: The differences between U.S. and European opinions on material toughness relate directly to a difference in philosophy. There are several differences, but the major difference is that the Europeans feel that the Charpy value relates to design while the U.S. opinion is that the Charpy test is a quality assurance exercise in sorting out "rogue materials." All other differences stem from that major premise.

Unfortunately, the technical justification of either of the requirements is unclear. The historical evidence indicates that both approaches are conservative since no API Specification 6A equipment failures have been attributed to brittle materials which met the requirements of the existing standards.

Therefore, the Task Group decided to start with a clean sheet and adopted the charge to "Determine what is necessary to prevent brittle fracture in the field."

Charge 4: With this charge in mind, the Task Group established work groups for:

- a. Literature survey.
- b. Literature evaluation.
- c. Correlations and calculations.
- d. Position paper containing proposed changes.

2 General History of API 6A/6D Activities Relative to Impact Testing of Materials

2.1 About 1969/70, at the API meeting in Los Angeles, a committee was set up to review the materials listed in API Specification 6A and Specification 6D for low temperature service. This interest was generated by the activities of the Alaska Pipeline Project.

2.2 The directions given by API committees were to review the materials listed in API Specification 6A and Specification 6D and to remove those materials which would not meet the standard Charpy V notch requirements of 15 ft-lb average, none less than 12 ft-lb at -20°F . The -20°F temperature was selected simply because that was the low end of the temperature range for API products at that time. In reviewing these materials, it became very apparent to the committee members that most of the materials listed would not meet the standard Charpy requirements at -20°F and that some of the materials were even questionable above $+32^{\circ}\text{F}$.

With this in mind, a call was put forth to all API members to report and document, if possible, any failures of API equipment which could be attributed to low notch toughness. No such failures were reported even in the Canadian or North Sea sectors. Since no failures were reported, and since it was well known that impact test values are generally considered relative in nature and are not used as a design tool, the committee was put in a quandary as to what action should be taken. There was considerable discussion on how the industry would react to removing a material from the API specifications which had been used very successfully for twenty or thirty years with no reported problems. and at the same time, support its existence and continued use in the field.

2.3 The final decision was to leave the need for impact testing at temperatures above -20°F up to the users, who could request impact testing at any temperature and stipulate any values they desired.

Equipment below -20°F would automatically require impact testing. The test temperature and energy requirements have changed somewhat over the years and have eventually evolved into the requirements of the current API Specification 6A and Specification 6D.