Alberta Municipal Affairs

ABSA
the pressure equipment safety authority

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Concerns about Carbon Steels with Low Toughness Properties

This Information Bulletin is issued to bring awareness to recent reports of industry experience with common carbon steel materials found to have unexpected low toughness values. Low toughness can result in brittle fracture of the material during hydrostatic tests, cold startups, or upset conditions that result in low temperature operations. This Information Bulletin also provides guidance to designers, owners, fabricators and repair organizations regarding the use of these materials (e.g. SA-105, SA-106, SA-234) with the codes of construction adopted in Section 6 of the Pressure Equipment Safety Regulation (PESR).

It has been reported that some flanges made of SA-105 material may have low toughness properties. Specifically, flanges made of SA-105 material may not be suitable for use at low temperatures down to -29°C (-20°F). This may be a concern since flanges made of SA-105 material are commonly exempted from impact testing per ASME Section VIII, Division 1 paragraphs UG-20(f), UCS-66, or ASME B31.3 paragraph 323 for temperature -29°C (-20°F) and greater.

Some SA-105 flange material has reportedly been impact tested as part of investigations into the low toughness concern. Results of the tests show that some flanges did not pass the impact tests at-29°C (-20°F). It is noted the same flanges otherwise met the chemical and mechanical requirements of the material specifications. Further testing has found some of these flanges have extremely low impact test values at -18°C (0°F) and warmer temperatures.

However, it has also been reported that testing of some SA-105 flanges resulted in impact testing that was satisfactory well below the -29°C (-20°F) exemption.

ASME code committees are aware of this issue and have opened several items to address it in the pressure vessel code and the process piping code. We understand proposals are being considered for code changes that may be introduced in the future code editions to address these concerns about low toughness. ABSA will continue to monitor the development of these proposals and will provide compliance information to all users when code changes are proposed.

Based on the industry reports, the following factors seem to contribute to low toughness values of carbon steels:

- Chemistry
    - presence of un-controlled elements that are acting as “micro alloys”;
    - reducing the manganese content, and adding other elements (e.g. boron) to obtain mechanical properties (e.g. SMUTS, SMYS, and elongation) required by the material specifications;
    - increase of carbon content;

    - incorrect data (chemistry) on the material test report (MTR) (e.g. data on the MTR does not comply with the obtained test results);
- Heat treatment (e.g. annealing, normalizing, or normalizing and tempering, or quenching and tempering)
    - heat treatment is either incorrect or has not been performed at all;
- Grain size
    - inadequate heat treatment results in a large grain size and low toughness;
    - inadequate manufacturing processes and/or heat treatments may result in microstructure and grain size that varies considerably within the same flange;
- Inadequate manufacturing processes that use tools (machines) that actually shape flanges in one tool strike;
- Material specifications do not specify minimum toughness requirements.

The uncertainty of not knowing if a particular flange, pipe or fitting made of these materials will be suitable for service at temperatures as low as the -29°C (-20°F) exemption is problematic.

This uncertainty leads to the need for more engineering analysis and good judgment. Simply relying on the impact test exemption provided in the Code may not be appropriate for all SA-105, SA-106 and SA-234 WPB products in all applications.

It is recommended that users, designers, fabricators and repair organizations carefully review the material toughness requirements on a case-by-case basis to determine if it may be in order to apply one or more supplementary material requirements, such as heat treatment (specifying normalized material), fine grain size, impact testing, manganese/carbon ratio greater than 5.0, and/or more restrictive chemistry requirements.

Fabricators should review carbon steel toughness requirements with the designer and the owner, and obtain their concurrence before applying the impact testing exemption allowed in paragraphs UG-20(f), UCS-66, UCS-67 of ASME BPV, Section VIII, Div. 1 or paragraph 323 of ASME B31.3. Owners, their designers or fabricator may consider the use of low temperature materials (e.g. SA-350 LF2, SA-333 gr. 6, SA-420).

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