MEETING TIME AND ATTENDANCE

The fracture mechanics subcommittee met in the afternoon of January 20 for approximately 4 hours. A total of 31 individuals attended the meeting. The attendance list is being transmitted to the secretary of the main committee separately.

DISCUSSION AND OUTCOME

1. Possible revision items of Annex A in support of the publication of 22nd Edition
   - A list with certain key parameters has been established. This list will serve to compile the items for possible revision.
   - A few possible revision items were collected at the meeting.
   - The list will be populated in the next 6 months. The subcommittee will review the list, rank the items, and develop a work plan in June/July of 2016.
   - It was agreed that members of the FM SC will perform joint review of essential variables in Section 12 and Annex A to ensure the Mechanized Welding SC and FM SC are working in the same direction.

2. Charpy tests – requirements for ductile behavior

   The requirement for 50% shear area was removed in the 21st edition. The shear area requirement in the Errata of the 20th edition was meant to ensure ductile behavior of girth welds. However the percentage of shear area in welds is difficult to read and the value depends on the individuals making the reading. While the subcommittee voted to remove the shear area requirement, it recognized that the required energy values in the 21st edition is too low for mechanized GAMW welds for ensuring ductile behavior. There is a gap left by removing the shear area requirement.

   Using lateral expansion as an indicator for material ductile behavior has been proposed as possibly a better alternative to shear area in prior subcommittee meetings.

   - Presentations of lateral expansion data were made by V. B. Rajan and Yong-Yi Wang.
     The available data indicated that the required lateral expansion for ductile behavior varies by type of pipes (vintage vs. modern pipe) and welding processes (manual SMAW vs.
mechanized GMAW). Based on the data shown, the implication is that using lateral expansion for Charpy criteria may experience similar challenges as does shear area. Potentially a lateral expansion value similar to ASME criteria (15-20 mils) could be specified for SMAW pipe welds and this criterion could ensure ductile material, but this value might represent the mid or lower transition of the DBTT curve for a very tough GMAW weld. In this case, a single criterion that works for SMAW would not necessarily ensure ductile behavior for other types of pipeline welds.

- More data are available at Exova and other organizations for review. David Chirichello of Exova will analyze the data with support from Robin Gordon and possible funding from API (Tim Burns will work on the funding). The data will be presented to the subcommittee after the analysis.
- It was suggested that requirements to reporting lateral expansion may be added in Annex A to encourage the collection of the data. The requirement for reporting lateral expansion in ASTM E23 will be checked.

3. **Implication of high CTOD value and with little tearing**
   - There have been instances that high CTOD toughness values (as high as 0.5 mm) were reported, yet the tests experienced little tearing and the CTOD was characterized as \( \delta_c \). This mostly occurs in high strength steels. Robin Gordon mentioned that this situation is similar to some Charpy tests, in which the impact energy is high but the shear area is low, e.g., 10%.
   - The implications of such CTOD were discussed. It was agreed that current ECA procedures in Annex A are still valid for this type of CTOD. The consequence of an event (failure) of such welds may be different from welds with “traditional” high CTOD toughness.
   - Tom, Robin, and Fabian will collect the data of such CTOD toughness and report back to the subcommittee.

4. **Strain-based ECA**
   - Names of those interested in strain-based ECA for onshore pipelines were collected.

5. **Discussion of CTOD retest criteria**
   - A question was raised about the retest criteria for CTOD testing in Annex A. There are currently no retest criteria (other than for replacement of specimens invalid due to such issues as improper machining or test equipment malfunction). It was stated that other test standards like BS 7910 have retest criteria including the option of running additional CTOD tests and then adopting a statistical approach for establishing characteristic toughness.
   - The absence of a retest criterion in Annex A is by design and represents a conservative approach. With this criteria, it is intended that if CTODs lower than desired are experienced (or lower than the 0.05 mm limit of Annex A), then possible recourse
includes determining the cause of the measured toughness, making improvements to the welding procedure, rewilding, and retesting.

- It was also pointed out that API 1104 Annex A represents an ECA procedure and not a fitness for service (FFS) procedure. FFS procedures are more typically used in individual cases where only one weld-stress-defect combination is being considered. Annex A toughness testing, once the welding procedure is qualified and tested, represents characteristic toughness for many future pipeline construction welds. The pipeline construction scenario requires a robust approach to establishing characteristic toughness for future construction.
- The concept of CTOD criteria was tabled for future discussion.

6. *Presentation by Yong-Yi on Linepipe and Girth Weld Failures*

- The issues highlighted in the presentation were well received.
- A primary point was made that in the case of unanticipated longitudinal tension or bending loads of a pipeline (say for the case of relatively minor settlement plus construction stress), girth welds with softened HAZs may be susceptible to failure. There was discussion on whether or not additional criteria for weld qualification would be prudent to mitigate this scenario.
- The pros and cons of different approaches were discussed. One approach would be to require no failure of a cross weld tensile specimen in the weld no matter the measured stress. The downside of this approach has been that in the case of pipe that is stronger than anticipated, a failure in pipe criteria can be difficult to accomplish for a weld otherwise suitable for the target pipe grade.
- Some mitigation options were discussed. It was agreed that the effects of all factors contributing to the failures should be considered as a whole. Eliminating one factor may or may not prevent the failures.
- The conundrum of unmanaged stresses, such as construction stress and stresses from differential settlements, potential girth weld failure due to soft/weak microstructure, and implications to 1104 or Annex A should be discussed further by members of this committee.

7. *ECA for Reeling Installation*

- A separate report is given by the task group chair Frans Kopp.