Part 1: Examples and questions

- How should the decision on the application of the Standard be made?

  Who is responsible for this decision?
- Who is responsible for the suitability of the material for the service conditions?
- What responsibility does the equipment manufacturer have in the material selection process?
- Is it sufficient to order equipment: “To NACE”?

Bullet 1: Evaluate the expected (or actual) service environment (See Clause 6).

Consider if any of the permitted exclusions allow equipment that does not comply with the standard to be used (See Table 1).

Consider if the use of any permitted exclusion is appropriate in terms of the risks of the local application.

All the above are the responsibility of the equipment user (See Clause 5).

Bullet 2: The equipment user, though he/she may enlist the help of the equipment supplier in the materials selection process (See Clause 5).

Bullet 3: The equipment supplier is responsible for compliance with the metallurgical requirements set out in the Standard.

Bullet 4: No. The equipment user has to have a much greater involvement than in the past because of the different environmental limits for crack resistance that are now considered to apply in particular for CRAs. The equipment supplier, equipment manufacturer or materials manufacturer will require information on the materials to use or on the environmental conditions of the intended service. (See Clause 5.)

Part 2: Examples & Questions

- Example 1:
  - A gas pipeline off of a separator has the following conditions:
    - 20˚C (68°F), 4 KPa CO_2 & 1 KPa H_2S
  - It is a short run of pipe and the only material available has a base material hardness of 270 HV10.
  - Is this acceptable?
  - Can we put in a Teflon liner and avoid the hardness issue?
  - The pipe has been cold bent to fit between the flanges. Any issues here?
  - A contractor has warned us that this pipe needs HIC testing and should have had a special chemistry. Is this correct?
  - What if the material has to be welded? Is this a show stopper?

Bullet 1: 1 kPa is greater than the sour service threshold for carbon and low alloy steels and therefore cracking resistant materials will be needed.

Bullet 2/3: In terms of Option 1 this material is too hard and is not acceptable (270 HV10 is equivalent to about 27 HRC; the limit for parent materials in sour service is normally 22 HRC).

In terms of Option 2 it might be possible to qualify this material for this low level of H_2S but given the apparent time pressure this is not really an option.

Bullet 4: No, coatings or liners are not acceptable methods to guard against sour service cracking. See A.2.1.5.

Bullet 5: There may be a problem with the effects of cold bending. See A.2.1.6.

Bullet 6: Maybe; if the pipe is seamless HIC is very unlikely and testing would not normally be done, if the pipe in longitudinally welded from carbon steel plate then HIC damage is much more likely and testing must be considered. See Clause 8

Bullet 7: In this the material described is already too hard for unlimited sour service. Weld hardness must always be considered and must be kept below 250 HV10. See 7.3.3, A.2.1.4 and Table A.1.

Part 2: Examples & Questions

A gas well with condensed water with a pH of 3.5 and PP_{H2S} of 3 psi has these casing requirements:

- Production liner with a minimum temperature of 65°C (150ºF) requires 105 ksi YS to resist burst failure.
  - What are acceptable casing grades?
- Can C-110 SS be used as a tie back to the surface at 4.5°C (40ºF) mudline temperature?
- If the casing can be set at 107°C (225ºF), can Q-125 be used?
  - Chemistry restrictions for purchase?

Bullet 1: Grades with sufficient yield strength that meet the requirements of Table A.3, Column 2 including A.2.2.3.2.

Bullet 2: No. C-110 is not considered suitable for the sour service conditions defined in this case, see Table A.3.

However, if the conditions are less severe, e.g. the conditions of pH and H_2S partial pressure in Region 1 of Fig. 1, it can be possible using Option 2 to qualify C-110 for use at the mudline temperature.

Bullet 3: Yes. Q-125 can be used above 107°C (225 °F) subject to Table A.3 Footnote b.

Part 3: Examples & Questions

- Example 1
  - 316 SS piping is suggested for a mixed phase oil stream downstream of a choke and going to a gas separator. Is this alloy acceptable?
    - Conditions of service 54°C (130°F), 14 psi H_2S, and 3.5 pH for oil !??
  - Gas off a separator has 25 psi H_2S? Is there a problem with using 316 SS piping?
  - There are 316 SS KO drums in between compressor stages in a sour gas system. Are these acceptable?

Bullet 1: Yes, Table A.1 refers to Table A.2 for "Any equipment or component". Table A.2 shows 316 to be acceptable up to 60°C (140°F) with 15 psi of H_2S. There are no limits placed on pH or chloride concentration.

Bullet 2: Assuming water separation is effective and less than 50 ppm chloride is achieved in the water phase, 316 can be used with unlimited H_2S at any temperature or pH. (See Table A.2.)

Bullet 3: Yes, Table A.1 refers to Table A.6 for compressors and this Table sets no environmental limits for 316 SS used in compressors.

Table A.4 also allows 316 SS for instrument tubing.

Part 3: Example 2 - Completing a gas production well

- We wish to choose the 80 ksi min. YS tubing and packer for a gas well.
  - Service conditions:
    - 10,000 psi BHP
    - 120°C (250 °F) BHT
    - 10,000 ppm chlorides
    - No elemental sulfur
    - 5% H2S

  What steps are necessary to enable a suitable choice of materials?

Step 1: Calculate the partial pressure of H_2S (See Part 2, Annex C).
10,000 psi x 5% = 500 psi H_2S (3,500 kPa)

Step 2: Assume that the use of a CRA is necessary for such extremely corrosive conditions.

Step 3: Consult Part 3, Table A.1; under “Downhole tubular components” reference is made to Tables A.19 and A.25 for high strength CRA tubing alloys. Note: Use can also be made of nickel based alloys that appear in Table A.14 under “Any equipment or component” for tubing applications

Step 4: Consider candidate materials:
Materials listed in Table A.19 are limited to 10 kPa (1.5 psi)
The super duplex stainless steels listed in Table A.25 are limited to 20 kPa (3 psi)

The cold-worked Ni base alloys, types 4c, 4d and 4e (See Table A.12 and Annex D, Table D.3) are acceptable for BHT of 120°C (250°F) (See Table A.14)

Step 5: For packers and other downhole accessories:
Many of the precipitate hardened alloys listed in Tables 31, 32 and 33 are suitable for use under the design conditions for this well. Alloys 718 and 925 are capable of being heat treated in thick sections and are regularly used for these components.