CORROSION RISK ASSESSMENT FOR OIL AND GAS PRODUCTION FACILITIES

METHODOLOGICAL APPROACH

General

The assessment of the corrosion risk is performed evaluating:
- the likelihood of occurrence of a corrosion event;
- the magnitude of the consequences of the corrosion event.

The following parameters are then defined:
- the *corrosion factor*, (F_C): it expresses the likelihood of occurrence of a corrosion event;
- the *overall consequence factor*, (F_{OC}): it expresses the entity of the consequences of a corrosion event.

The *Corrosion Risk* is defined as the product of the likelihood of occurrence of a corrosion failure or event, expressed by the *corrosion factor*, F_C, by the entity of the consequences of the corrosion failure or event, expressed by the *overall consequence factor*, F_{OC}.

$$\text{Corrosion Risk} = F_C \times F_{OC}$$

Figure 1 illustrates the standard procedure followed for corrosion risk assessment execution.

Corrosion factors

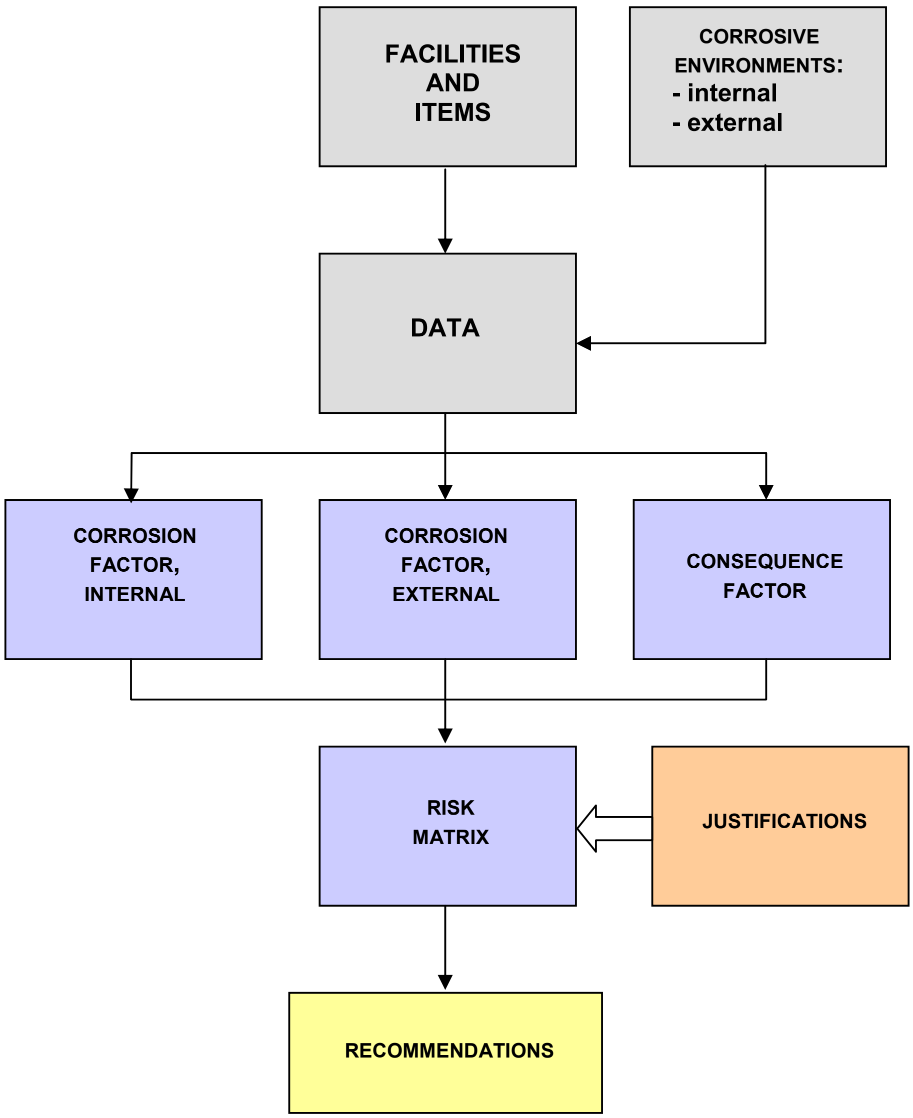
The corrosion factor, F_C, is calculated based upon the corrosion rate, CR (mm/y), the available corrosion allowance, t_{CA} (mm), and the design life, DL (years). It is defined as:

$$F_C = \frac{10}{DL} \times \left(DL - \frac{t_{CA}}{CR} \right)$$

F_C is a parameter expressing the corrosivity of the environment with respect to the fitness of the corrosion control methods; it is related to the likelihood that the corrosion allowance is consumed during the design life.

The corrosion factor F_C calculated by the above formula is a number varying from negative to +10:
- negative values represent over-design conditions: the available corrosion allowance is greater than necessary to cover the design life;
- a corrosion factor of zero represents the optimum case, with corrosion allowance exactly consumed at the end of the life of the facility under study;
- positive values of the corrosion factor represent cases where the corrosion allowance is not enough to last for all the design life. A corrosion factor of 10 represents that the corrosion rate is quite high with a consumed thickness at the end of the life not compatible with the available one.

Figure 1 – Corrosion risk assessment: execution procedure.



Two cases are covered:
- new facilities: t_{CA} is the design corrosion allowance and DL is the full design life;
- existing facilities: t_{CA} is the residual corrosion allowance and DL is the residual life.

The corrosion rate CR (internal or external) is taken as the maximum value among the calculated corrosion rate for each corrosion form, v_i:

$$CR = \max. (v_1; v_2; v_3 \ldots v_i)$$

Above criterion applies typically to carbon and low alloy steel.

If rules or algorithms are not available to calculate the corrosion rate, as it is the case for instance of corrosion resistant alloys, the corrosion factor value is assigned based on empirical / subjective rules.

In case of existing facilities, the calculated corrosion rates are verified with respect to inspection and corrosion monitoring data.

Internal and external corrosion are always handled separately; occurrence of internal and external corrosion at same position of a given item is excluded *a priori*.

Internal corrosion and protection

Internal corrosion analysis will be based on corrosion forms.

The following ones will be considered:
- CO_2 corrosion
- H_2S corrosion, including:
  - uniform and localised;
  - SSC;
  - HIC;
  - amine
- Erosion corrosion
- Erosion (sand)
- O_2 corrosion
- Microbial.

For each form of corrosion, algorithms and rules will be provided in the knowledge specification, suitable to calculate the corrosion rate v_i.

For each corrosion form, prevention methods will be considered, including:
- Fluid treatment with corrosion inhibitors;
- Fluid treatment with biocide;
- Fluid treatment with oxygen scavengers;
- Cathodic protection by galvanic anodes;
- Coatings;
- Material selection.

External corrosion and protection

The following external corrosion forms will be considered:
- soil corrosion, including:
  - oxygen;
  - microbial;
  - stray current;
  - carbonate bicarbonates
- sea water corrosion, including:

- oxygen;
- microbial.

For each form of corrosion, algorithms and rules will be provided in the knowledge specification, suitable to calculate the corrosion rate.

For each environment, the following prevention methods will be considered:
- Cathodic protection, by galvanic anodes or impressed current;
- Coatings.

Materials

Internal and external corrosion assessments are referred to carbon and low alloy steels, taken as *base material* for oil and gas production facilities.

However, corrosion resistant alloys (CRA's), extensively used in production facilities (well tubing, flowlines, piping and vessels, etc.) will also be considered.

For CRA's, performance of a given alloy is basically expressed in terms of resistance or not to a given environment. The corrosion factor is assigned, independently from design life and corrosion allowance, equal to 0 (safe) or to 10 (unsafe).

Overall consequence factor

The consequences in case of uncontrolled failure or event due to corrosion are grouped into the following categories:
- hazard to the safety of people;
- operability;
- environment.

To assess and quantify the consequence of failure, the model adopts numerical consequence factors between 0 (lowest or no consequences) to 10 (maximum consequences). The consequence factor, F_{CO}, is made up of the contribution (weight) of the three factors:
- hazard consequences;
- operability consequences;
- environmental consequences.

In the event of a failure, the overall consequence is given by the sum of the weights of the three influencing factors as follows:

$$\underset{\mathbf{0 \rightarrow 10}}{F_{OC}} = \underset{\mathbf{0 \rightarrow X}}{F_H} + \underset{\mathbf{0 \rightarrow Y}}{F_O} + \underset{\mathbf{0 \rightarrow Z}}{F_E}$$

where:
F_{OC} = Overall Consequence Factor
F_H = Hazard Consequence Factor
F_O = Operability Consequence Factor
F_E = Environmental Consequence Factor
X+Y+Z = Maximum value of F_{OC} (10)

The three consequence aspects are considered independently from each other and then aggregated to obtain the overall consequence factor. The physical factors contributing to hazard, operability and environmental consequence are identified and ranked in order of importance with numerical values assigned accordingly.

Risk matrix

The calculated corrosion and consequences factors are used to position a given item into the *corrosion risk matrix* (see Figure 2).

On the corrosion risk matrix different zones are defined, corresponding to different levels, or *classes*, of corrosion risk.

On a corrosion risk matrix more facilities or items are normally represented.

The criteria adopted to group more items on same matrix shall be defined case by case by the user. For plant units, for instance, the criterion normally adopted is to represent on separate matrixes the piping and the vessels. Obviously, the grouping on same matrix shall be done for homogeneous items only.

Separate matrixes are always issued for internal and external corrosion.

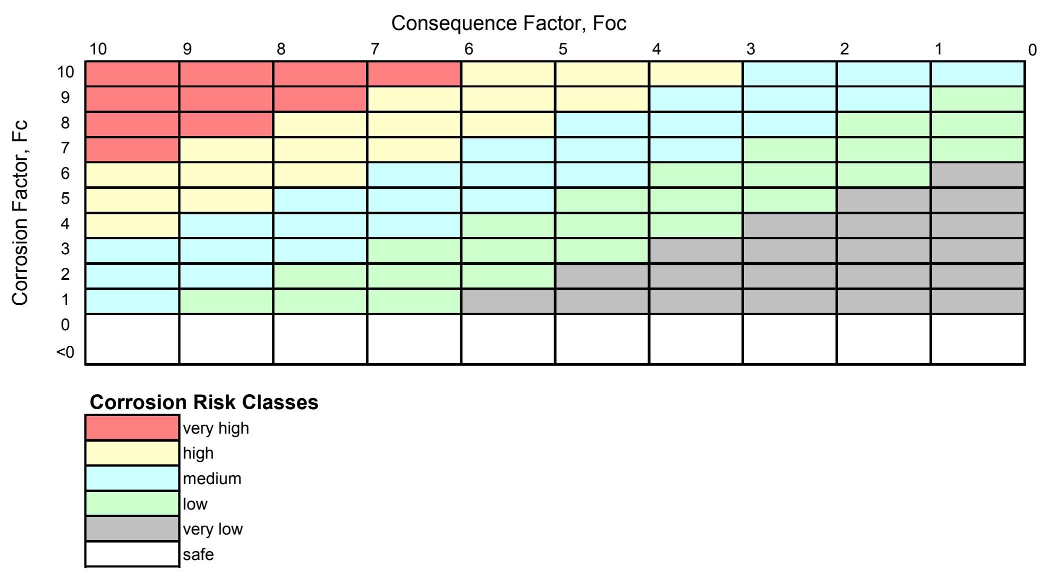


Figure 2 – Corrosion risk matrix and classes of risk.