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MATERIAL SELECTION
AN OVERVIEW OF THE PHILOSOPHY AND METHODOLOGY

Presenter: Alan Hunter

CEng, CChem & CSci

Principal Consultant - EconEng Ltd

INPUTS REQUIRED BEFORE STARTING A MATERIAL SELECTION

Ask the client the following questions:

- What is the purpose of the system/item?
- What is the required design life?

  (before any life extension exercises)
- What is the owner's / client's attitude to the trade off between Capex and Opex?
- When does the system need to be available?

  (this reflects procurement schedule).
- Where will the system/item be constructed or fabricated?

  (will skilled labour be available)

Based on the answers to these questions a "Material Selection Philosophy" should be developed for client approval.

(the client may be a third party company or the requesting dept.)

The Philosophy will generate more input questions.

Does the client have a preferred Corrosion Management Philosophy?

Primarily this will reflect two approaches.

→ Cheap (Capex) carbon steel with a through life requirement for corrosion mitigation

→ Expensive (Capex) Corrosion Resistant Alloys (CRA's) with limited through life mitigation (Opex)

(Based on this generate Life-Ex costs if required)

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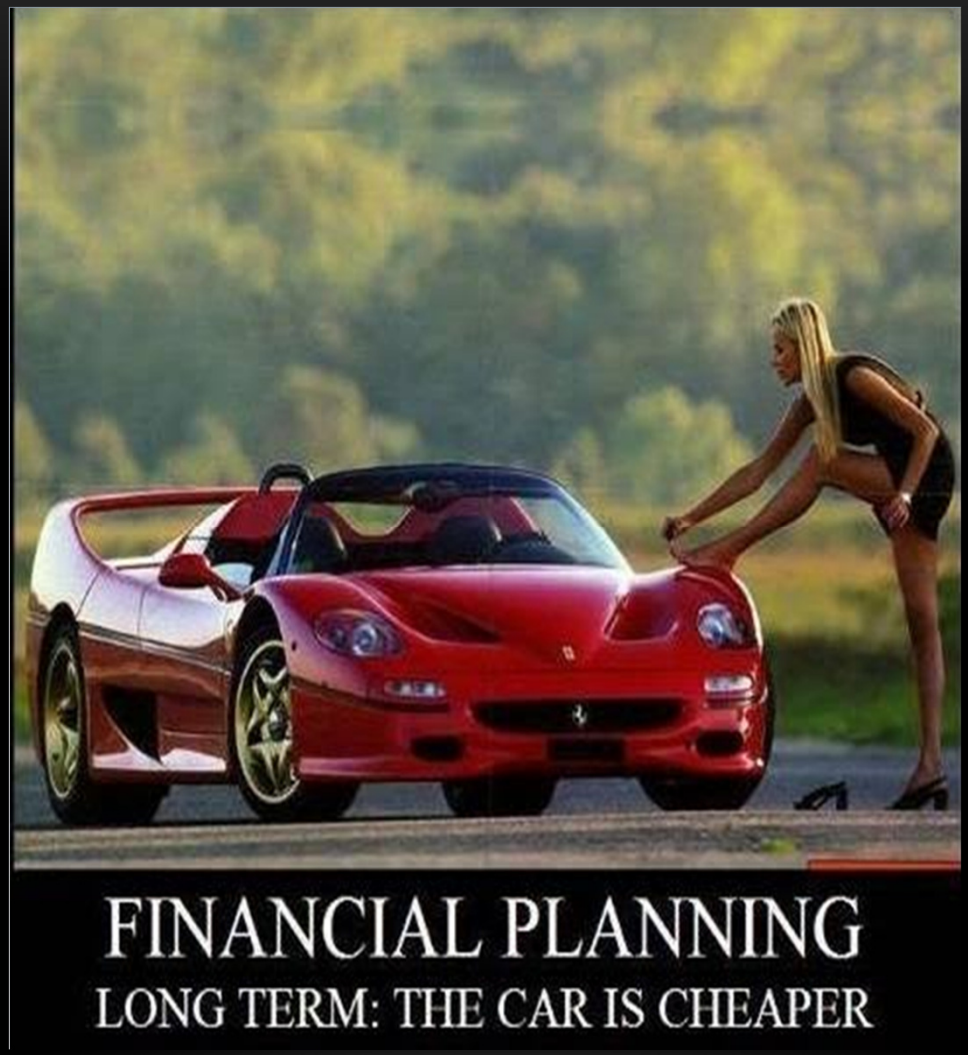


Physical Constraints

- Location Environment (external corrosion)
- Internal Process Fluids Environment (internal corrosion)
- Max/Min Temperature (impact on rate of corrosion)

The above answers and input enable the degradation / corrosive mechanisms to be considered and suitable Materials of Construction to be selected for consideration.

External

DEGATION / CORROSION MECHANISMS + THREATS

These threats will reflect the physical location of the system and its environment.

What chemicals and temperature will contact the surfaces of selected materials?

The impact of those will be affected by the material selection – Carbon Steel (CS) or Corrosion Resistant Alloy (CRA)

Atmospheric Factors

Gaseous Pollution : H_2S, CO_2 , acid fumes etc.

Marine Environment : Salts , Na Cl, etc.

Inland Continental : No salts / sometimes dry

Water (precipitation)

Ambient Temperature (range)

(Process driven temperature range)

Thermal Insulation – (CUI)

Atmospheric Considerations

A normal design's premise – Protective Coating (paint) means there will be zero external corrosion.

This is standard – but not practical.

Coating breakdown occurs and painting (fabric maintenance) is a poor relation in the O+G operations budget (sometimes even in construction).

If CRA's are selected, Stress Corrosion can be a risk, often requiring the use of coatings to mitigate it.

This creates an ongoing maintenance (Opex) cost.

If the CRA is under insulation, inspection costs further increase.

(Carbon steel starts to look more attractive, because the CRA will probably have to be painted anyway – after the "Project" has been handed over to the "Operations")

Immersion Considerations

Normal design premise is that protective coating and/or Cathodic Protection (CP) means there will be zero external corrosion.

Again, common but not always practical thinking.

Immersion coatings (protective and or insulation) tend to last longer than atmospheric ones (better than exposed paints).

Cathodic Protection (CP) generally is effective.

However CP shielding can and does occur rendering some localised areas at risk of corrosion.

New designs – Local proximity anodes ☺ But for retrofits there is a move to a "Remote" skid anodes (increased risk or shielding) ☹ – a debate to be aware of.

Process / Internal Considerations

What corrosive (oxidising) chemicals will contact the Selected Material surface (inner of the containment envelope) and what are the likely degradative effects?

List potential failure mechanisms and state how they are mitigated by material selection and/or other means.

Impact Of Process Conditions On Failure Mechanisms

- Need to know min + max operation temperature.
- Will the process steam contain free water (Dewpoint)?
- Can process operations induce temperature excursions and Joule Thompson cooling / auto refrigeration?
- Need to know min + max design temperature.

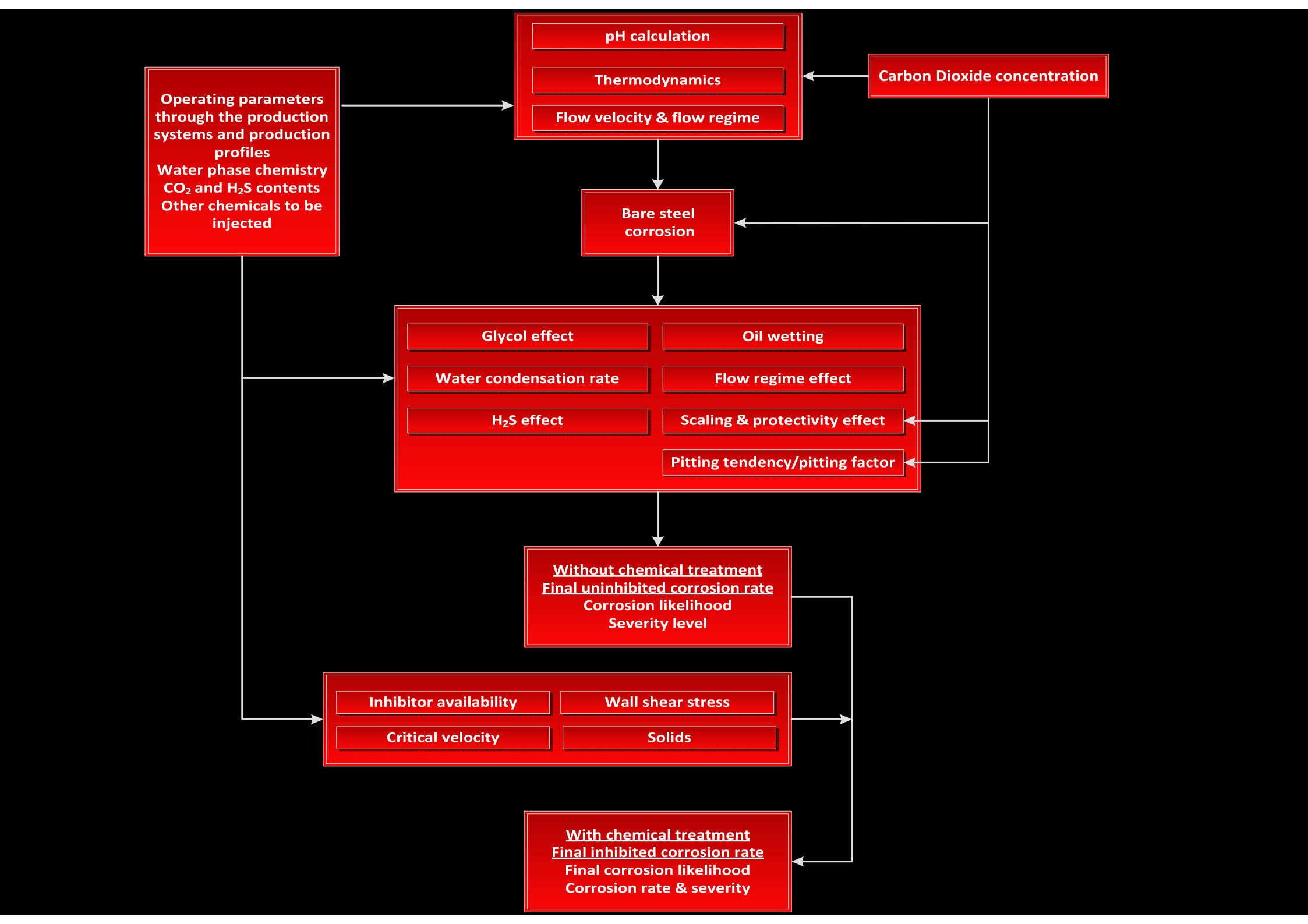
CARBON DIOXIDE (CO_2) : WHAT IS THE THEORETICAL RESULTANT CORROSION RATE (TO CARBON STEEL)?

Determine this based on use of the following models.

a) De Waard and Milliams.
b) Norsok M506
c) Client preferred / proprietary software

- (remember theses are just guides - be cautious of trusting fully)

MODELLING CARBON DIOXIDE INDUCED CORROSION


pH calculation
Thermodynamics
Flow velocity & flow regime
Carbon Dioxide concentration
Operating parameters through the production systems and production profiles
Water phase chemistry
CO_2 and H_2S contents
Other chemicals to be injected
Bare steel corrosion
Glycol effect
Oil wetting
Water condensation rate
Flow regime effect
H_2S effect
Scaling & protectivity effect
Pitting tendency/pitting factor
Without chemical treatment
Final uninhibited corrosion rate
Corrosion likelihood
Severity level
Inhibitor availability
Wall shear stress
Critical velocity
Solids
With chemical treatment
Final inhibited corrosion rate
Final corrosion likelihood
Corrosion rate & severity

Based on theoretical material wall thickness loss, select either a Corrosion Resistant Alloy (CRA) or a Carbon Steel with appropriate mitigation.

Define the mitigation mechanisms / treatment – Chemical inhibitor – dehydration – coating / lining or low temperature etc.

Not only must the corrosion rate / mechanism be considered but so must erosion.

Various models can be used.

API 12 E is a reasonable starting point.

However clients have their own models (TULSA).

As a rule of thumb, Carbon Steel is used for topside / surface equipment if a mitigated corrosion rate and a 6mm corrosion allowance will achieve the design life (say 20 years).

If not – use a CRA.

Subsea equipment material selection is more complex.

The use of carbon steel may occur with greater corrosion allowances (up to 12mm).

This is driven by the cost or pipeline / riser and subsea system components – particularly CRA ones.

Thus far we have not discussed composite materials (plastic based).

Although these are potentially practical they are unpopular in the Oil and Gas industry.

There is scope for future application and career making.

Aluminium has never taken off (apart from in the aviation industry).

Design and Installation contractors don't like innovation (though they don't say this).

Reason: Increased personal and corporate risks, (both like "their" bonuses)

New materials imply new and unfamiliar design codes.

Workforces are unfamiliar with their application.

The site of fabrication can present labour skill shortages.

Applies if the Project is “small” and the location does not have an established work force

(take note if it’s a retrofit to a plant).

SUMMARY

- Establish inputs requirements from client.
- Establish clients “spend” philosophy.
- Select in accordance with above to meet design intent at least life cost.

  (Life Ex)
- For an open client explore if “new” materials are cost advantageous.
- Consider fabrication practicalities.

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A little thought

"Corporate rules"

A turkey was chatting with a bull.

'I would love to be able to get to the top of that tree' sighed the turkey, 'but I haven't got the energy.' ‘

Well, why don't you nibble on some of my droppings?' replied the bull. They're packed with nutrients.'

The turkey pecked at a lump of dung, and found it actually gave him enough strength to reach the lowest branch of the tree.

The next day, after eating some more dung, he reached the second branch.

Finally after a fourth night, the turkey was proudly perched at the top of the tree.

He was promptly spotted by a farmer, who shot him out of the tree.

Moral of the story:

Bull Shit might get you to the top, but it won't keep you there..

Consider this as you generate your Material Selection Guide.

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