Professional paper
UDC: UDC: 620.197.2:662.951.23
DOI: 10.7251/afts.2014.0611.051B
COBISS.RS-ID 4572696

SELECTION CASING MATERIAL DEPENDING OF WELLS FLUID CORROSIVITY

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ABSTRACT

World production of pipes is mainly based on the standards of API. However, this does not obligate you to use exclusively for casing manufactured by API standards. The wells that will exploit the hydrocarbons and aggressive media, install the protective casing made of alloy steel not yet covered by API standards. Running casing operation holds a special place in all phases of the wells because of protective casing account for a high percentage of the cost of drilling and improperly designed pipe string (or damaged by corrosion) increased costs due to repair of the object. If the fluid layer which produce, present aggressive gases (CO_2, H_2S, Cl), under certain thermodynamic conditions, it may cause significant corrosion of pipe materials. That created openings in the casing string may allow migration of gas. For this reason it is necessary to know the limits specified partial pressures of gases and estimate conditions in which corrosion is expressed.

Key words: *partial pressure, corrosion, casing, hardness, hydrogen sulphide*

INTRODUCTION

The most common gas migration in the annulus between tubing and production casing is the leaking of the tubing which can result from a poor tread connection, corrosion, thermal-stress cracking or mechanical rupture of the string. Gas migration in the outer annuli, outside of the production casing, is result from a poor cement job or from its damage during the production life of the well. During the cement job, the bond can be compromised in several ways, the most common being the invasion of gas into the cement during the setting process. Cement can be also damaged by operations after the cement has set:

- mechanical impact occurring during tripping drill collars, stabilizers and other tubelars,
- expansion and contraction of casing and cement sheath due to changes in pressure and temperature: this can result in the separation of the casing from cement,
- execution of casing pressure tests, conducted to confirm the competency of each string and also performed prior to perforating, fracturing and after setting packers or bridge plugs,
- high pressures occurring during acidizing, fracturing, cementing and Frac-Pack operations.

CASING MATERIALS

Material selection for setting the casing and equipping wells with aggressive gases should be given special attention. It is necessary to do all the preparations that are necessary for the accurate prediction of corrosion and then by selection of materials. In fact, already in the works, in some wells, creating the conditions for corrosion of pipe materials as shown in Table 1. Gas manifestation, [1] ie. increase in the concentration of gas in the mud, registered the gas detector by increasing the gas deflection curve. The gas curve indicates the gas a few manifestations:

BG - the gas that remains in the system after the execution of drilling mud degazolination and re-pumped into the well,
TG - the gas that is held in open-hole part of the borehole, the drilling stage, when there are no delays due to replacement chisels, testing, EK measurements
NG - the gas that is released from new drilled layer, ie. gas that penetrates into the mud when drilled formation is saturated with hydrocarbons,
CG - the gas that is made in the bottom of the borehole at:

a. by pulling out the kelly due to the addition of new drill pipe,
b. the pressure drop in the space caused by an interruption of circulation mud due to the addition of new drill pipe,
c. a combination of the impact previous two cases.

Table 1 Summary of the relative concentration of gas in the explored borehole X

Depth (m)	BG (%)	TG (%)	NG (%)	CG (%)	Gas composition (%)
3360 - 3414	0.5 - 10				C_1, C_2, C_3, $_iC_4$, $_nC_4$
3367			5		$C_{1= TRAG}$, $C_{2=0.09}$, $C_{3= 0.05}$
3374		30			C_1, C_2, C_3
3380			17		$C_{1= TRAG}$, $C_{2= 0.07}$, $C_{3= TRAG}$
3403			17		$C_{1= 0.25}$, $C_{2= 0.22}$, $C_{3= 0.15}$, $_nC_{4=8}$
3414			100		$C_{1=8}$, $C_{2=10}$, $C_{3= 10}$, $_iC_{4=6}$
3415		100			C_1, C_2, C_3, $_iC_4$, $_nC_4$

Materials for protective pipe in the borehole due to their chemical composition, are divided in the following manner:

- carbon steel,
- low alloy steels,
- alloyed steels,
- high-alloy steels,
- materials in which iron is the main ingredient.

Each pipe manufactured to API standards celebrated monogram American Petroleum Institute. Monogram obliges producers and controllers that the product meets the API standards.
For protective tube API is standardized:

- the length of the tube,
- quality steel,
- outer diameter,
- thickness of the pipe wall,
- threaded fittings.

The quality of steel (Figure 2) determines the basic mechanical properties of the tube, and adding ingredients steel and heat treatment leads to improvement of primary mechanical and chemical properties. API standards [2] specify the minimum and maximum requirements for quality steel casing, as shown in Table 2.

Table 2 Maximum and minimum values of elasticity for different qualities of steel casing

Steel qualities	Elasticity limit Min (bar)	Elasticity limit Max (bar)	Minimum border breakout (bar)
H - 40	2759	-	4138
J - 55	3793	5517	5172
K - 55	3793	5517	6552
C - 75	5172	6207	6552
L - 80	5517	6552	6552
N - 80	5517	7586	6897
C - 95	6551	7586	7241
P - 110	7586	9655	8621
Q - 125	8621	10690	9310
V - 150	10345	-	11034

Table 3 shows the hardness of materials as the composition [3], which is one of the important criteria for selection of materials (in the case of the presence of H_2S in the fluid layer).

Table 3 Hardness of the function of the chemical composition of steel

Materials	Hardness Rc
Carbon steel	22-23
Low alloyed steel	do 26
Alloy steel	22-23
Highly alloyed steel	depends on the alloy composition
Materials with less iron	depends on the alloy composition

Carbon steel N - 80 and C - 95 are resistant [4] to corrosion only at temperatures higher than 65°C.
Carbon and low alloy steels are susceptible to general corrosion and spot type and are not recommended for installation when the natural gas contains large amounts of carbon dioxide and chloride in the presence of formation water (Table 4). In such cases is mandatory to use corrosion inhibitors.
Alloy steels containing 9 - 13% Cr, and very often used for tubing and parts preventer devices.

Table 4 Limit values aggressive fluids when use alloy steel

Aggressive component	Limit for alloy steel
CO_2	Partial pressure up to 100 bar and temperature up to 150°C
H_2S	Partial pressure < 0,01 bar
CHLORIDES	Up to 30 g/l at 150°

High-alloy steels are resistant to all types of corrosion. It should be noted that the high temperature adversely affects the strength of the material. For some materials, a significant loss of strength and can be over 25% at a temperature of 200°C.

EFFECT OF CARBON DIOXIDE (CO_2)

The corrosivity dependence CO_2 from the partial pressure [5] is shown in Table 5.

Table 5 The corrosivity dependence CO_2 from the partial pressure

Partial pressure	Corrosion CO_2
> 2 bar	Corrosion
0,5 - 2 bar	Possible corrosion
< 0,5 bar	Non corrosion

The partial pressure is expressed [6] as the ratio of a gas component to the total gas mixture:

$$Partial\ pressure = mixture\ pressure \cdot \frac{part\ of\ volume\,(\%)}{100}$$

HYDROGEN SULFIDE EFFECT (H_2S)

The effect of hydrogen sulfide can cause several types of corrosion:

- Corrosion general type - can occur only in the presence of water and is particularly strong at temperatures higher than 93°C (Figure 3). It is electrochemical corrosion, whose product (ferosulfid) deposition on the metal surface in the form of black sludge and becomes the cathode compared to non corroded material, which is subject to corrosion as the anode. Corrosion occurs when the partial pressure of H_2S greater than 0.01 bar (Table 6).
- Dotted corrosion - corrosion is similar to a general type, there is a very small part of the surface material. Despite slight loss of material may pose a significant risk due to the high penetration depth.
- Stress corrosion - stress corrosion cracks occur due to the simultaneous effects of sulfide chemical environment and mechanical stresses. This type of damage is directly caused by the penetration of atomic hydrogen in the alloy structure, the molecular recombination of atomic hydrogen, which leads to cracking of metals at low stresses.
- Destruction metal by hydrogen - atomic hydrogen as a product of a general type of corrosion, penetrates into the metal lattice, where recombination of molecular hydrogen and causes cracking in the metal as a result of the increase of the internal stress of metal volumetric expansion of molecular hydrogen.

At temperatures above 80°C the destruction of the metal hydrogen [7] significantly decreases the transition temperature range (65°C - 80°C) fractures rarely occur, and the real danger of destruction of metal hydrogen begins just below 65°C.

Stress type of corrosion as well as the destruction of the metal hydrogen are not subject to carbon and low alloy steels, except with hardness exceeding 22 Rc.

Table 6 Dependence corrosivity of hydrogen sulfide partial pressure

Partial pressure	Corrosion H_2S
> 0,01 bar	Corrosion
0,01 - 0,001 bar	Possible corrosion
< 0,001 bar	Non corrosion

Low pH water (Table 7) in the fluid layer [8] are ideal conditions for H_2S corrosion.

Table 7 Dependence pH of formation water and the degree of corrosivity H_2S

pH formation water	H_2S corrosion
Up to 6,0	H_2S corrosion area
6,0 - 9,5	Damage from H_2S corrosion is rare
above 9,5	No damage due to corrosion H_2S

CHLORIDE AND FORMATION WATER ACTION

Chlorides cause corrosion of two types:

- Corrosion general type that results in the dotted surface appearance with a very small deep defects,
- Stress corrosion that results in profound changes in the metal lattice, causing a fracture of materials at low stress.

Formation water in the form of condensate, or in its original form, it is very important for the prediction of corrosion (Figure 4). She is a poorly mineralized condensate, while in all other cases it can be very mineralized, and contains minerals that affect its pH. Dissolved CO_2 lowers the pH value of formation water, thus creating ideal conditions for H_2S corrosion if there is presence H_2S (Table 6). Higher NaCl and $CaCl_2$ content [9] in the brine reduce the impact of carbon dioxide on the pH value.

Due to the presence of very corrosive drilling fluids attached Block diagram (Figure 1) will enable the correct choice of casing material.

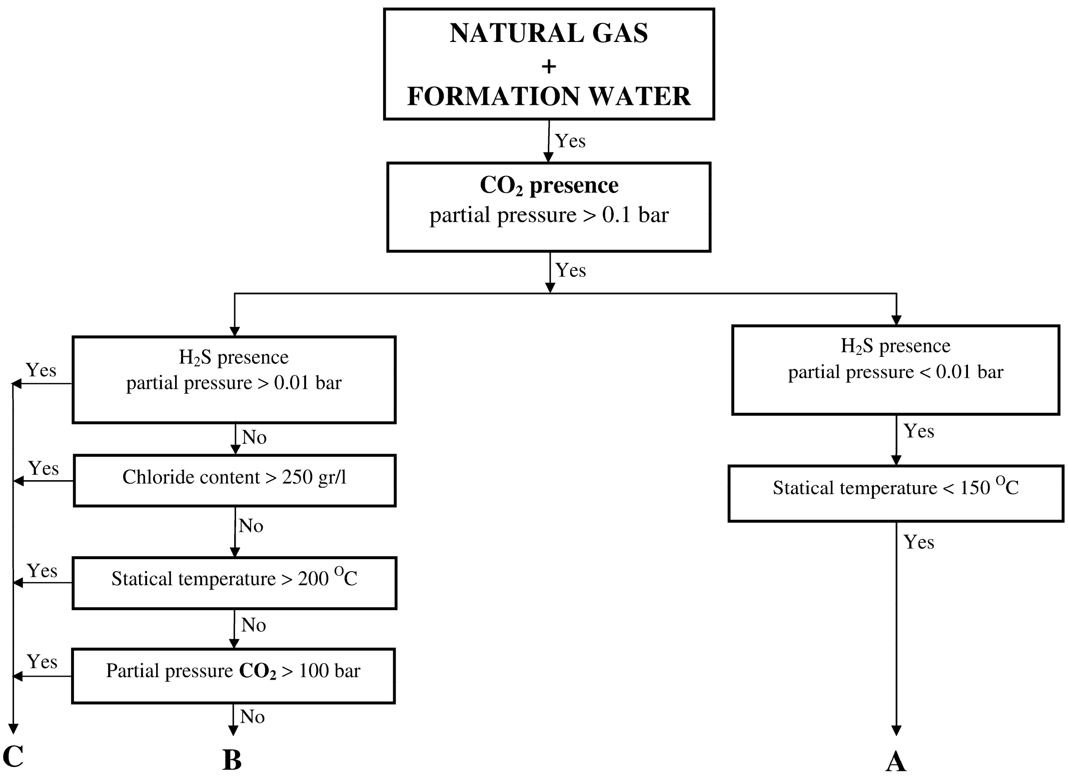

Figure 1 Block diagram for the selection of pipe material

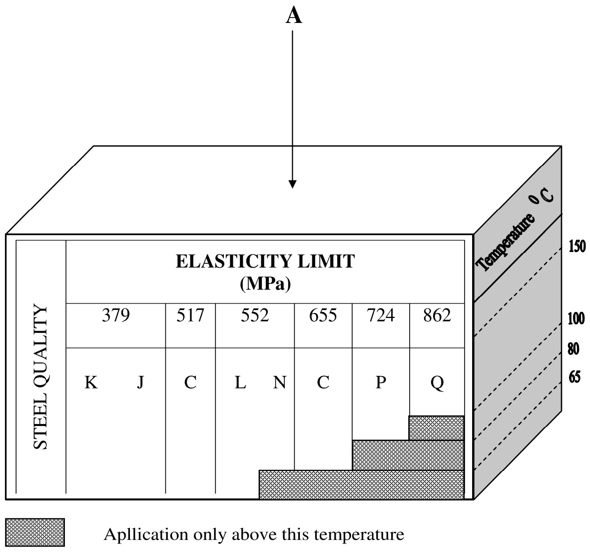

Figure 2 Casing materials selection according Block diagram

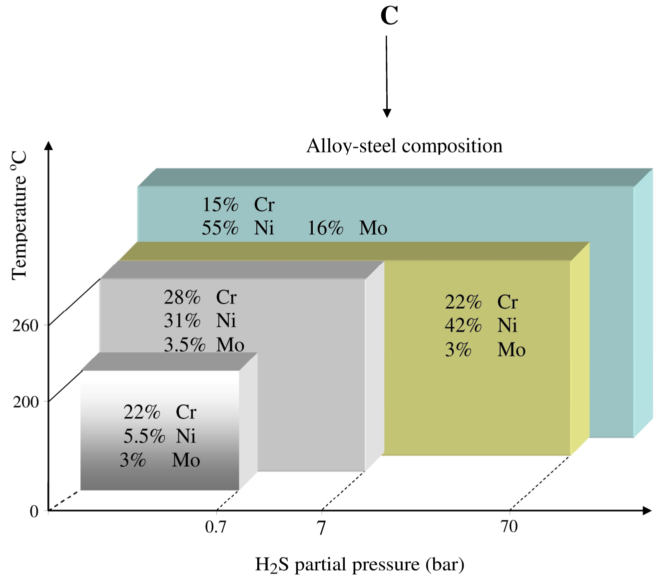

Figure 3 Casing materials selection according Block diagram

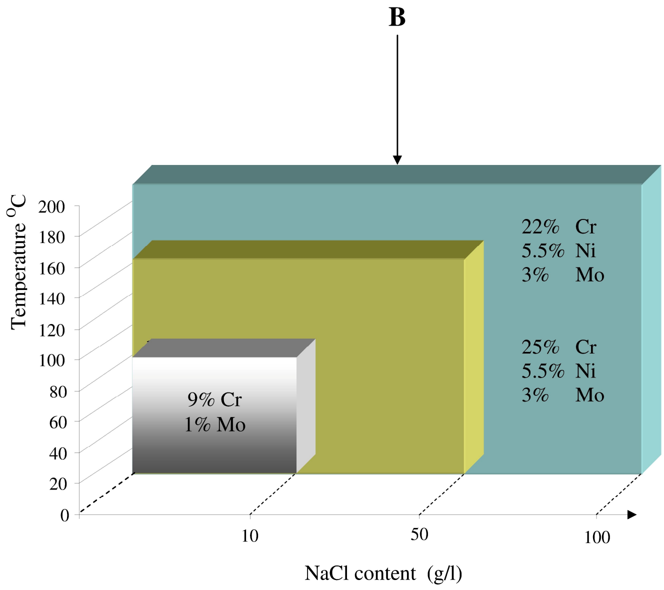

Figure 4 Casing materials selection according Block diagram

CONCLUSION

Assessment of drilling conditions is extremely important because it affects the production, security and economics of the wells. It contributes not only to the fact that during operations in wells made certain well conditions but also of the fact that the well correctly produce during lifetime. Still in the design phase, particularly stress in the borehole during production all the elements that make up must be correctly specified in order to maintain security. The average time to failure is now about 30 years compared to ten to 15 years in thelate 1970's and early 1980's. Drilling and completion practices have improved, reducing the failure rate and increasing the average age of the well before failure.

(Received 10. January 2014, accepted 14. February 2014)

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