

EMPHASISE OF SOME PECULIAR ASPECTS OF A PIPELINE CORROSION DAMAGE DUE TO CITADINES WORK CONDITIONS¶

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Abstract: The paper presents the results of a case study of a failure analysis on a pipeline component serviced about 20 years in an underground structure for oil transportation, between a railway station and a thermal power plant, as result of interaction with urban environmental attack.

Keywords: Pipeline component, carbon steel; oil transportation; steam; corrosion; environmental attack

1. BACKGROUND

In considering the wide area of problems rised up by the failure of the specific pipeline, it has to be considered at least:

- a) The design parameters
 - external diameter of pipe, 219 mm;
 - wall thickness: 8 mm;
 - maximum allowed pressure for oil transportation as well as for steam purging: 1 MPa;
 - maximum service temperature: 120 °C for oil transportation and 250 °C for speam purging;
 - steel quality, carbon steel OLT 35K as conforming STAS 8184:89
- b) The work parameters
 - environmental conditions;
 - history of operation;
 - history of maintenance

2. EXPERIMENTAL

2.1 By visual analysis

In order to assess with accuracy the place of failure and establish the most representative pipe damaged elements, some special works were needed to be undertaken in – place, especially in order to do not disturb the urban circulation, as well as the riparian's property.

It was just the opportunity for a direct collaboration between scientists and technical representatives from the pipeline owner. All these activities have resulted on some stages of in-place inspections, adequately registered and sintetized in fig. 1 to 3.

As general remarks, some peculiar aspects are to be emphasised:

- a) the transportation pipeline was commissioned in 1988;
- b) the permanent corrosion protection was an bituminous coating supplementary reinforced by wire nets and mineral/glass fibber; the effectiveness of this protective system is high to be discussed, since only few small traces were still present at the time of the assessment (as shown in figure 4).



Fig. 1 – Generals aspect of the location – access to the failure zone



Fig. 2 – The failure zone – external detail



Fig. 3 - The failure zone – internal detail



Fig. 4 – The failure zone – external detail, traces of protective system

- c) the main oil transportation system was assisted by a stem heating an circulation system which at the time of the assessment was un operable; few stem pipelines of smaller diameter were also damaged, but no connection between these and the oil transportation pipeline failure could be made;
- d) the oil transportation pipeline was an underground type, located in concrete channels on two separated branches, in order to prevent the total fall down of the system; along about 25 m the pipeline was transverse disposed to a main city circulation road were two tram lines were active; the last rehabilitation of these lines, including the high voltage supplying and transportation lines being performed in 1996;
- e) the two oil pipelines, branches of the same system, were nor perfect symmetrical, the branch quoted P1 being deeper, since P2 (with the final failure – figure 3), being 2 m upper to the road level; the level difference between the two branches was solved by elbows, but no corrosion or mechanical damages were identified for these elbows;
- f) no general corrosion, even internal (figure 2), or external (figure 1) was present;
- g) due to the steam circulation, some interesting indents aspects were registered even far from the damaged area (figure 4); such internal aspects were also present in the area of failure, but here the indents disposition has followed the stem un regular circulation (figure 5);



Fig. 5 – The external detail, steam indents



Fig. 6 – The external detail, steam indents, irregular

- h) the failure place was at about 2 m from the nearest tram line in a region at 13 – 14 hour, where the wall thickness was about 1 mm as results of external consumption; some corrosion products were present; the main corrosion mechanism was of an anodic consumption due to the interference between the pipeline and the high voltage supplying system;
- i) the failure was an time dependent process, since the rupture scenario have followed at least few stages, like figure 7 allow to interpretation:
- wall thickness consumption from the external side, till a critical thickness in respect to the actual rezistance properties;
 - explosive failure, by overloading, with important deflection;
 - continual wall degradation during operating in such condition till a total damaged surface of about 100 mm², when the fluid lost was significant and environment was affected;



Fig. 7 – The external detail, failure

2.2. Assessment of the steel pipe actual properties

In order to assess the steel pipe actual performances a program of chemical, mechanical and microscopic analysis was performed, but here only mechanical and microstructure results are emphasised, because a very interesting behaviour occurred.

As shown in table 1 and 2 during tests at 250°C an important enhancement of measured values occurred. It was doubled by an important instability during the temperature test in the yield point region, in a range of about 2000 N.

Table 1. Tensile testing at room temperature

Pipe marking	Specimen position	T (°C)	Specimen direction	Specimen type	R _{p0.2} (N/mm ²)	R _m (N/mm ²)	A ₅ (%)
P1	P1 –9 hour	+20	Longitudinal	Strip	320	436	24
P1	P1 –15 hour	+20	Longitudinal	Strip	309	425	33
P2	P2 –9 hour	+20	Longitudinal	Strip	307	425	31
P2	P2 –15 hour	+20	Longitudinal	Strip	309	422	36
Prescribed values (+20°C) – STAS 8184-89:					Min. 255	450...550	Min. 21

Table 2. Tensile testing at high temperature

Pipe marking	Specimen position	T (°C)	Specimen direction	Specimen type	R _{p0,2} (N/mm ²)	R _m (N/mm ²)
P1	P1 –9 hour	+250	Longitudinal	Strip	288	494
P1	P1 –15 hour	+250	Longitudinal	Strip	277	515
P2	P2 –9 hour	+250	Longitudinal	Strip	279	498
P2	P2 –15 hour	+250	Longitudinal	Strip	282	492
Prescribed values : STAS 8184-89: OLT35K					Temperature + 250 °C	Yield strength , R _{p0,2} , N/mm ² , min. 185

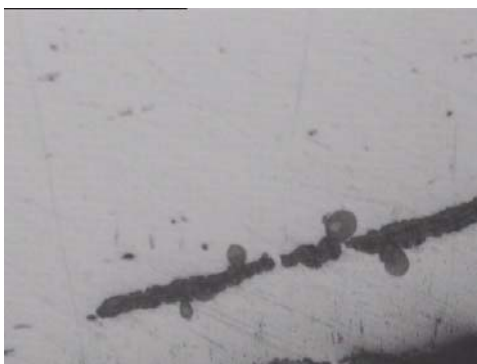


Fig. 8 – Steel impurities, unetched x 100

Such behaviour was considered in relationship with microstructure aspects, where sulfide plastic impurities were spectacular growth, and it could be explained only by hydrogen atoms trapped at these impurities, release due to testing conditions (250 °C and 45 minutes heating duration).

3. DISSCUTIONS

Some discussions can be made in relation with the design solution, which 20 years before have prescribed a steel grade for thermal working, and no one for oil transportation.

The steel pipe failure is due to external corrosion, and the mechanism of interference with high voltage systems is evident.

The future maintenance have to consider a active process of hydrogen arrest into sulfide plastic impurities that are now at an important size even in longitudinal and transverse directions.

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