



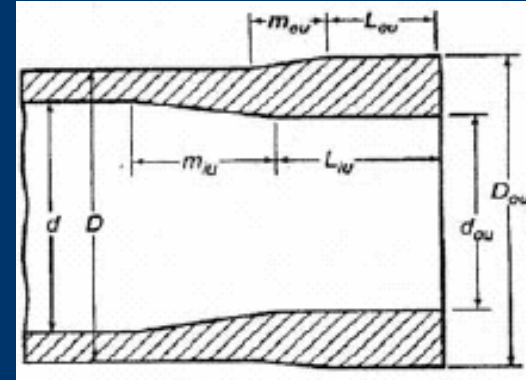
Romanian Association
of Drilling Contractors



Petroleum-Gas University
Ploiesti, Romania



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RESEARCHES CONCERNING THE FREQUENCY OF THE DRILL PIPES FAILURES

Researches Concerning the Frequency of the Drillpipe Failures

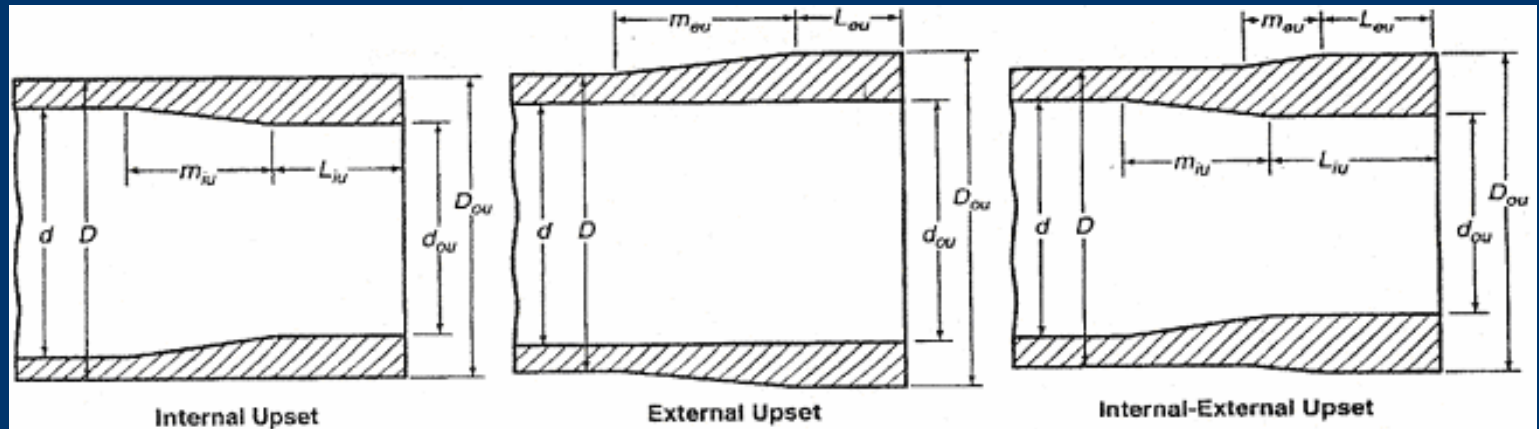
Geometry of the Upset Drill Pipe End

Main geometrical parameters of the transition zone:

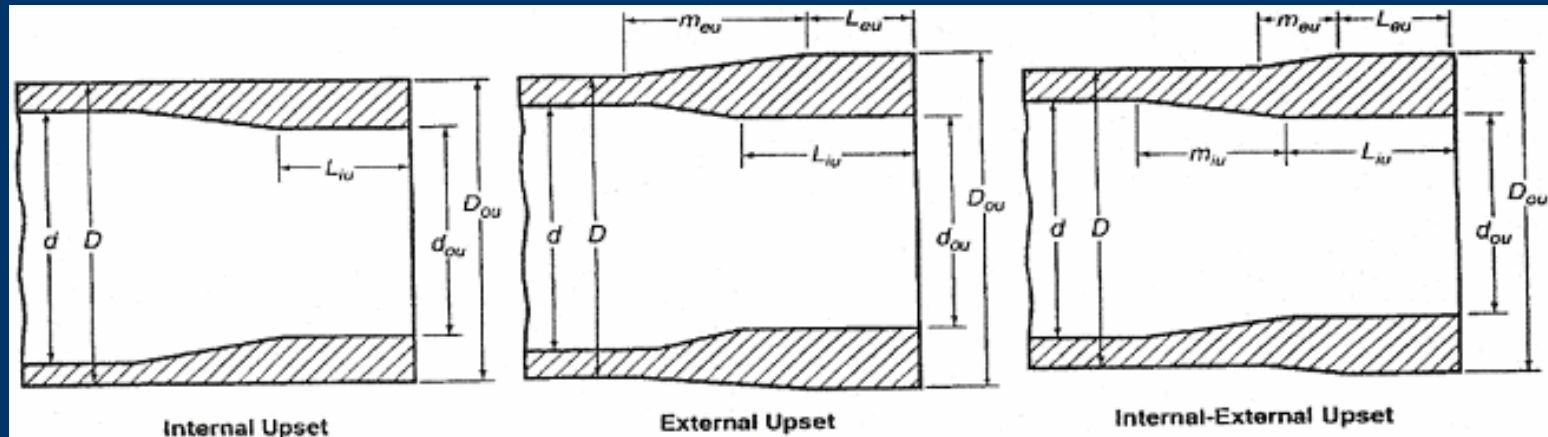
m_{iu} – length of internal taper zone,

R – connection radius between the transition zone and drill pipe body

Group 1 –
grade E



Group 3 –
grades X, G, S





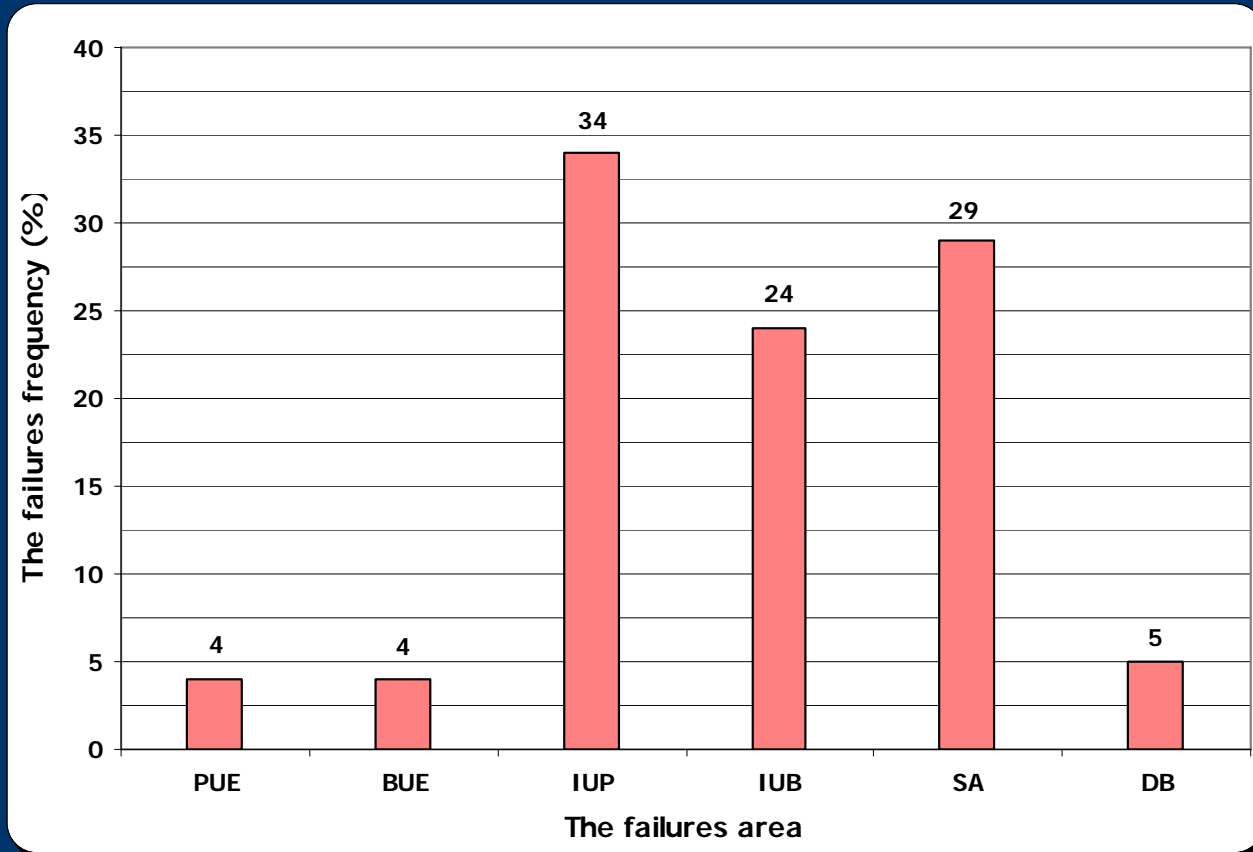
Researches Concerning the Frequency of the Drillpipe Failures

- **Our researches: a statistical analysis of drill pipe failures recorded in Romania, and experimental investigations regarding the geometry of the drill pipe upset end (the main failure point).**
- **In order to increase the drill pipe fatigue life, we propose the increase of the material toughness, the elaboration of fatigue life calculation procedures based on the recorded history of drill pipe loadings, and the optimization of the constructive shape.**
- **Worldwide investigations regarding drill pipe failures tried to correlate the drillpipe fatigue life and the geometry of the internal upset of drill pipes.**



Researches Regarding Drillpipe Failures Performed Worldwide

The Position of Failures from the Andarko Basin Area



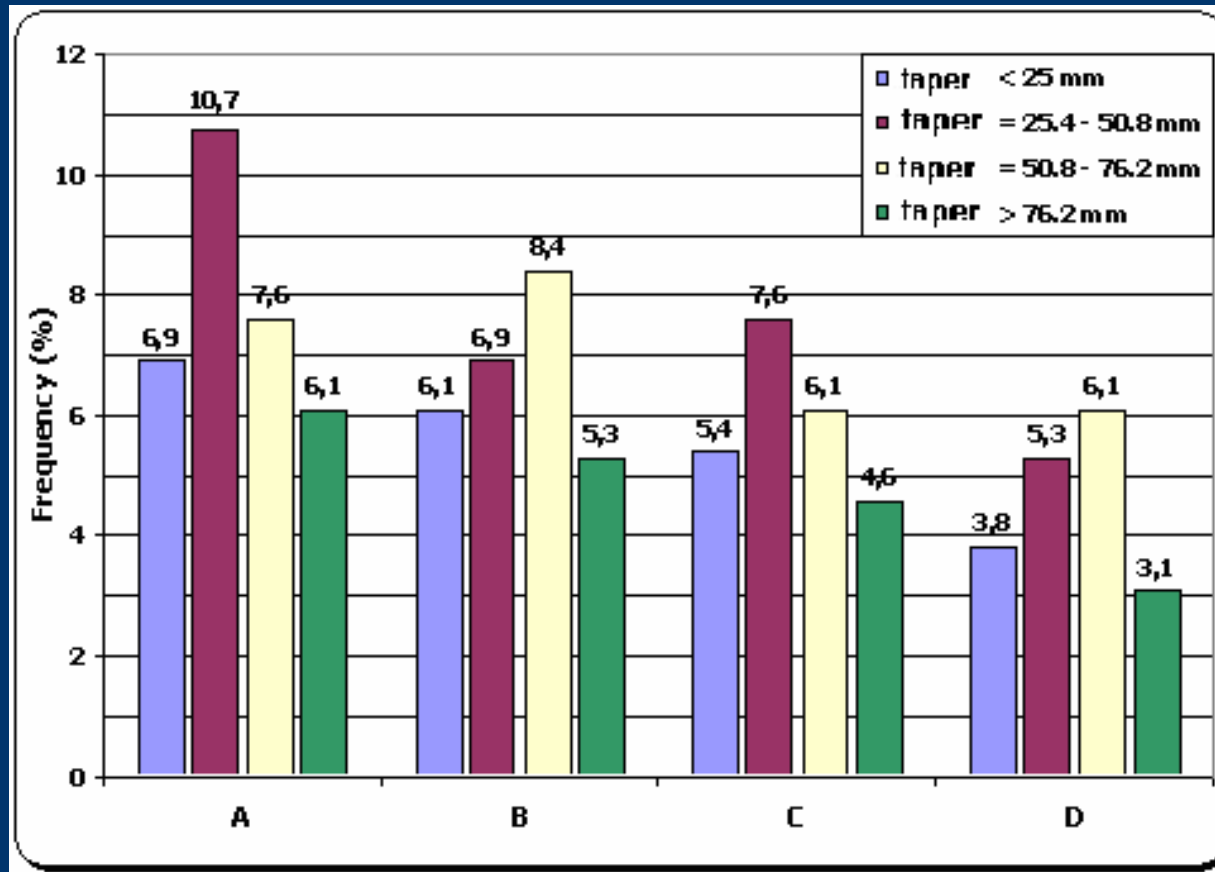
**PUE – pin upset end joint; BUE – box upset end joint; IUP – internal upset to pin;
IUB – internal upset to box; SA – slips area; DB – drill pipe body**



Researches Regarding Drillpipe Failures Performed Worldwide

The Distribution of the Values of the Internal Taper Length, m_{iu}

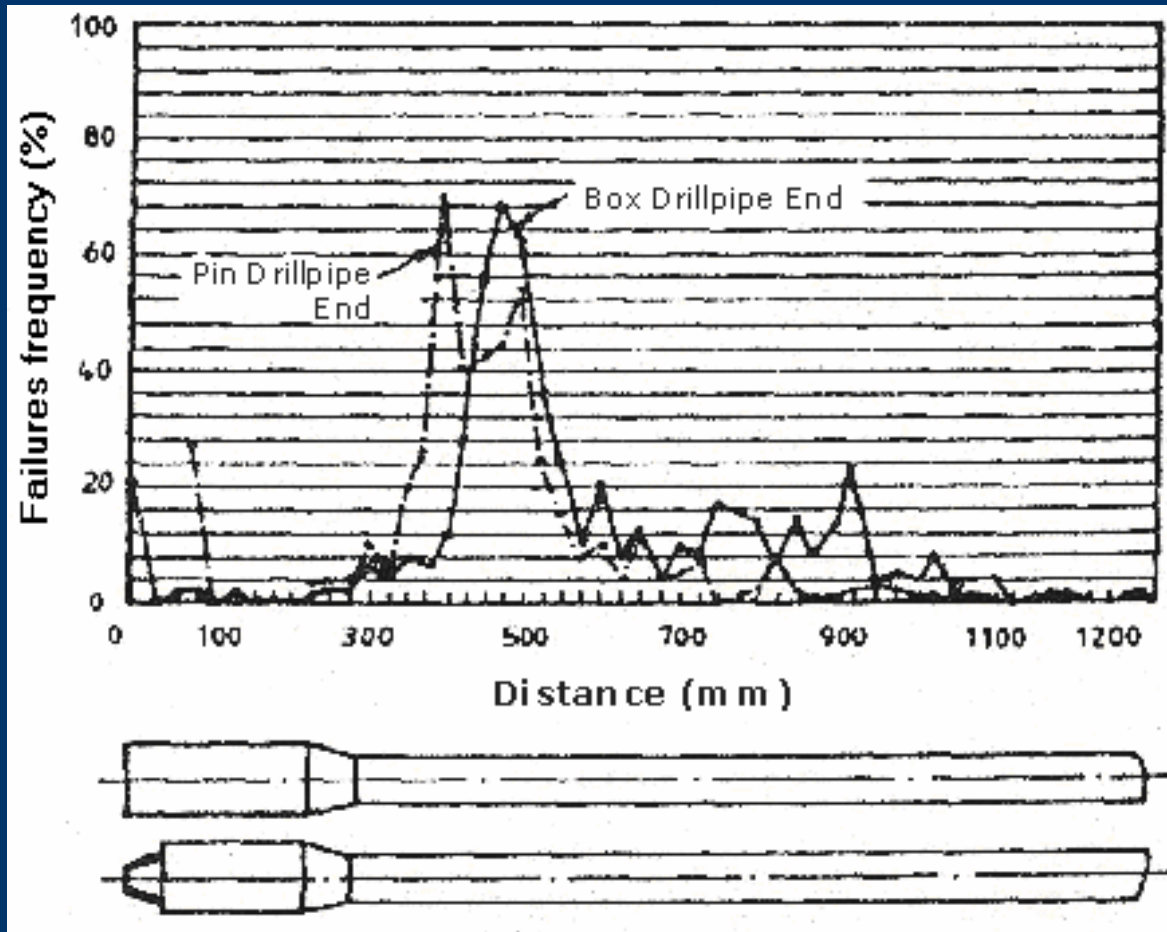
for 4 different suppliers (A, B, C, D), according to Noble Drilling Corp.



Small m_{iu} values are much more frequent among broken drill pipes

Researches Regarding Drillpipe Failures Performed Worldwide

The Drillpipes Failures Frequency versus Distance from the Pipe End,

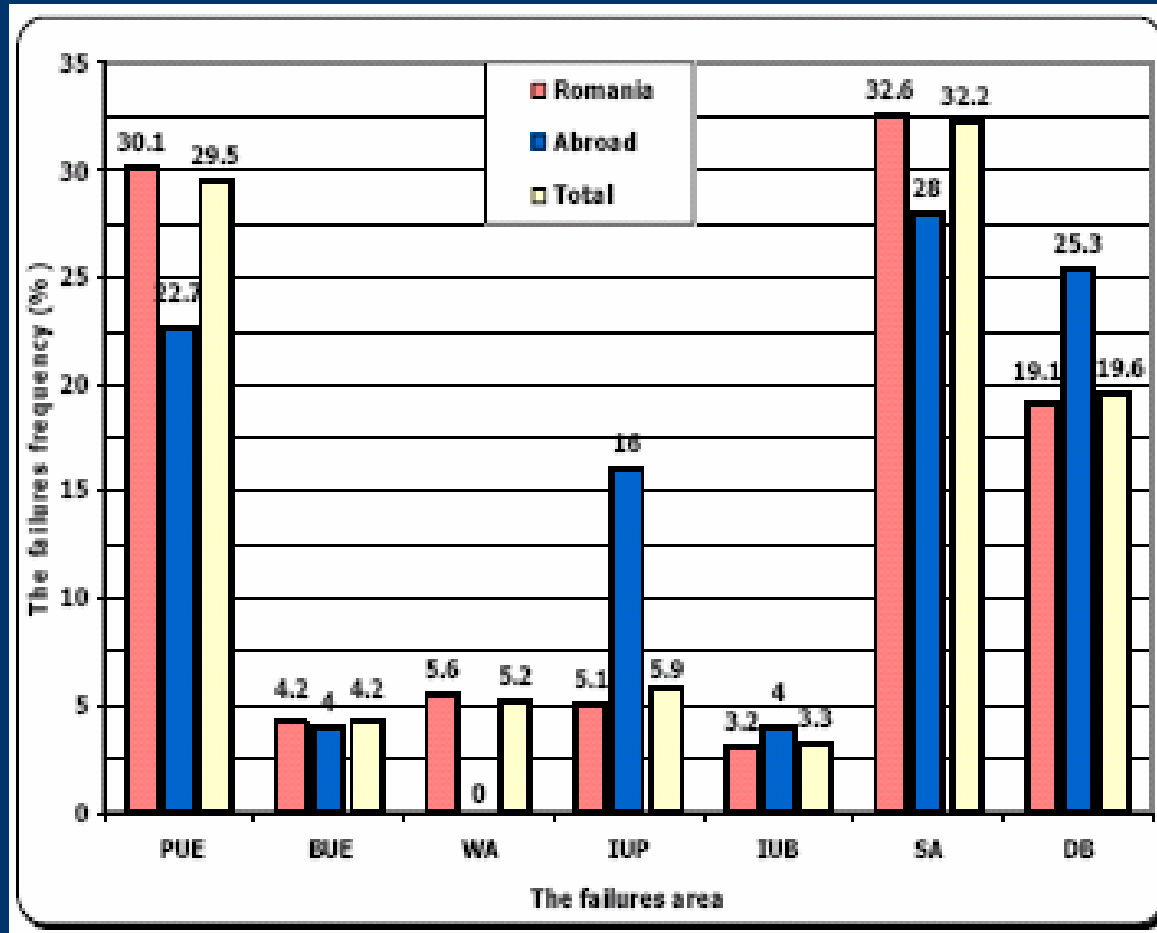


*according to
API/IADC,
without taking
into account the
failures caused
by the slips
action upon drill
pipes body*



Statistical Analysis of Drillpipe Failures from Romania

The Position of Failures from the Romanian DP Ground



PUE – pin upset end joint; BUE – box upset end joint; WA – welding area; IUP – internal upset to pin; IUB – internal upset to box; SA – slips area; DB – DP body



Statistical Analysis of Drillpipe Failures from Romania

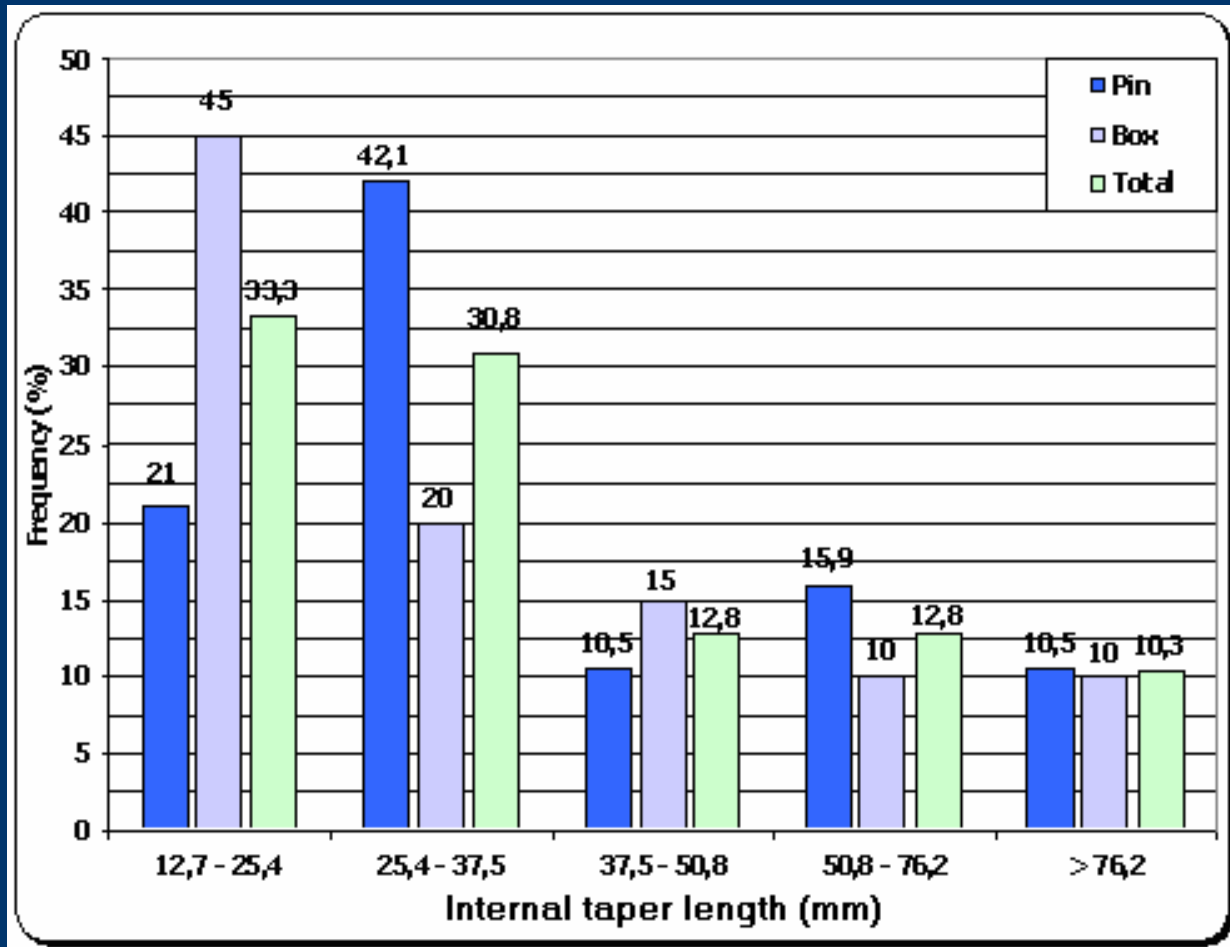
Conclusions

- Most failures (92%) occurred at the 5 in DP (127 x 9.19 mm), most used in Romania.
- The slips area is the critical point, with a failure frequency of 32.23%, especially of the Romanian drill pipe manufactured in, as a result of inadequate handling.
- A great number of failure was produced at the pin upset end joint (29.53%), for all drill pipes.
- In the case of Romanian DP a non-allowable number of failures were recorded in the welding area (5.63%), which emphasized some deficiencies of the used welding technology.



Experimental Research of the Geometry of the Upset Drillpipe End

The Statistical Distribution of the Internal Taper Length Values, m_{iu} , for Both Ends of 5 in DP





Experimental Research of the Geometry of the Upset Drillpipe End Conclusions

- At about 75% from studied drill pipes, the registered values of m_{iu} were smaller than the limit recommended by API 5D, 76.2 mm (3 in). As a consequence, most of the investigated drill pipes are predisposed to fatigue failure starting in the internal upset zone of the drill pipe ends.
- There is no significant difference between the values of m_{iu} at the same drill pipe.
- There is not a clear trend regarding the value of m_{iu} at neither one of the producers (the investigated drill pipe were supplied by seven different producers).



Researches Concerning the Frequency of the Drillpipe Failures Conclusions

1. The great majority of DP failures occur in the transition zone (internal upset area), starting from inside.
2. In order to avoid such failures, many companies performed statistical analyses showing that the frequency of failures increases while the internal taper length decreases.
3. The correct measurement of the internal taper length is difficult due the complexity of the plastic deformation process.
4. After many statistical analyses, and measurements performed on several DP batches, it resulted that, in 70% of all failure cases, the internal taper length was smaller than the limit of 76.2 mm, recommended by API 5D.
5. As a consequence, we propose, also in order to be more self-confident, a minimum value for the internal taper length of 88.9 mm (3½ in).



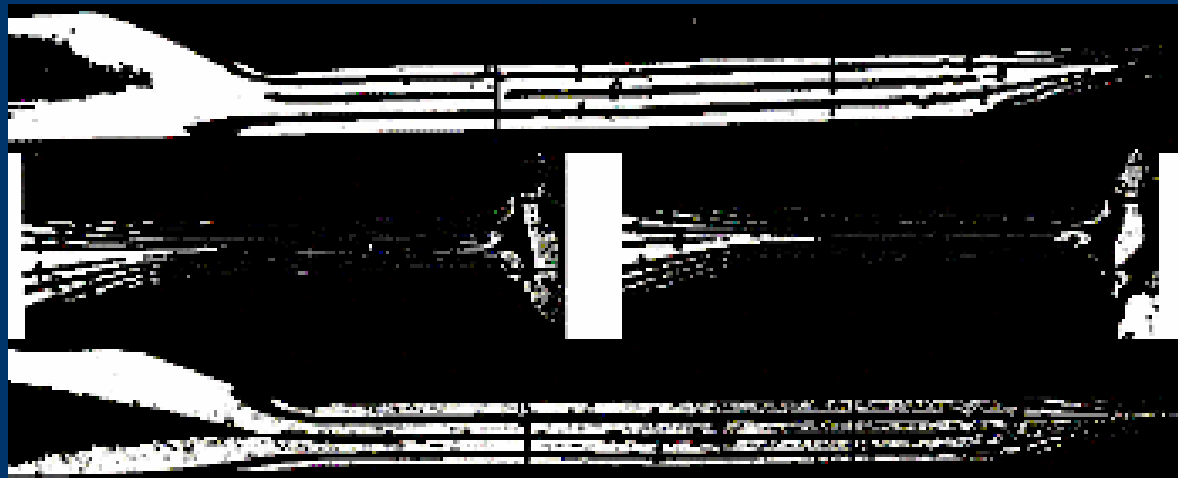
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CORRELATION BETWEEN THE DRILL PIPE UPSET GEOMETRY AND ITS FATIGUE LIFE



Correlation between the Drillpipe Upset Geometry and Its Fatigue Life

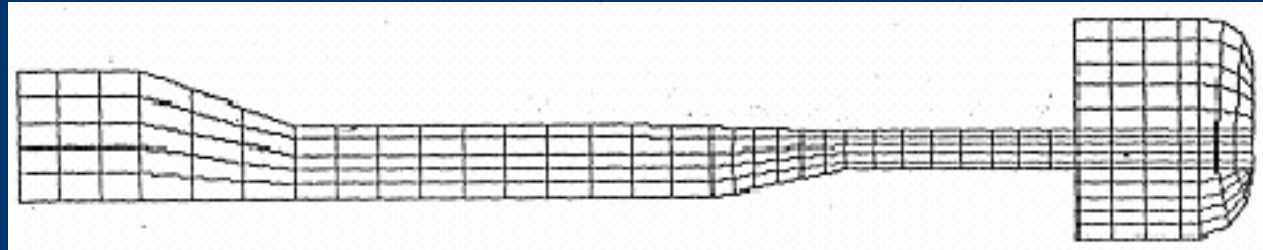
- Both in Romania and abroad, a lot of companies are faced with premature failures of drill pipes causing technical accidents. The average cost of such failures amounts to 106,000 USD.
- Investigations performed in China, confirms the possibility to increase the fatigue life of drill pipes 8 – 26 times by re-designing the shape of the internal upset zone.
- Drill pipe failures are initiated inside the upset zone and there is a direct correlation between the geometry of the internal upset and the fatigue life of the drill pipe. This confirms that the transition area from the drill pipe upset end to the drill pipe body has an effect of stress concentration.



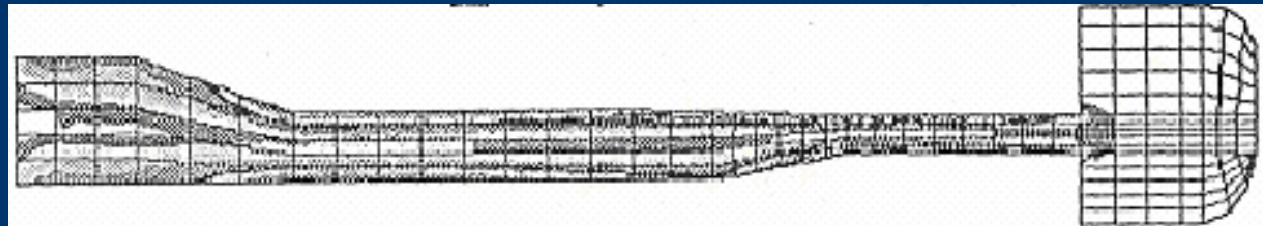
Stress Analysis in the Upset Drillpipe End Area

FEM Analysis of the Upset Drill Pipe End

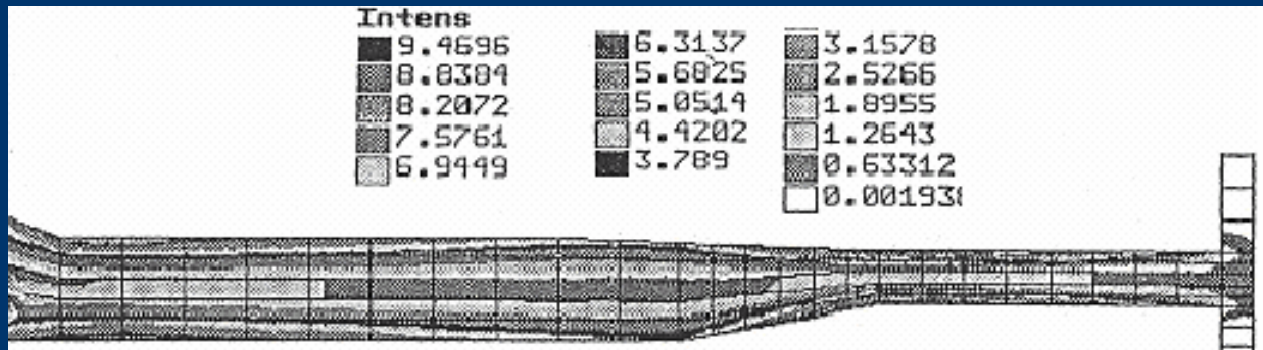
FEM Model



Stress Analysis Results



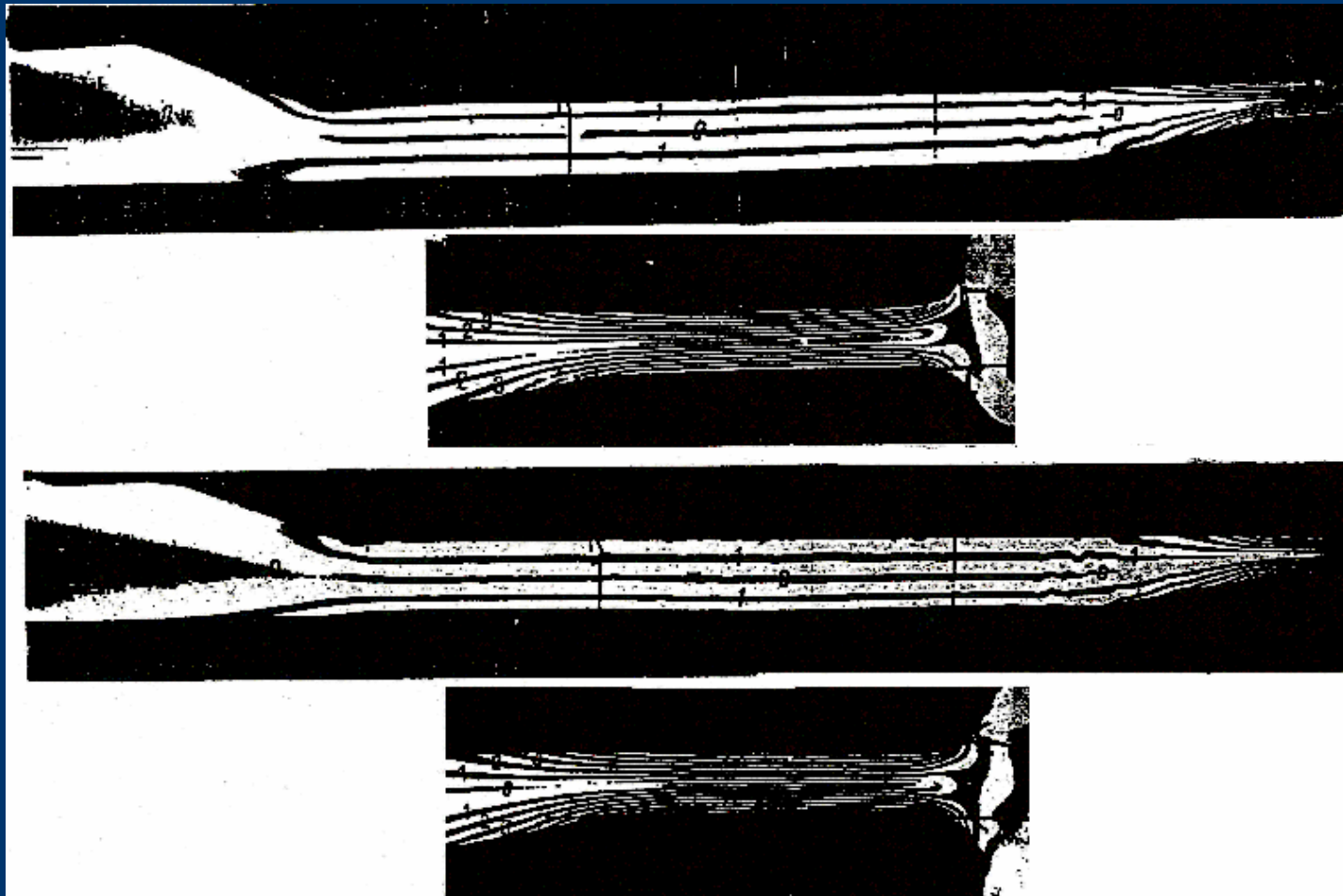
Detail of the stress concentration zone





Stress Analysis in the Upset Drillpipe End Area

Photoelastic Pattern under Pure Bending Effect
isochromatic curves





Stress Analysis in the Upset Drillpipe End Area Conclusions

- The comparison of maximum stress values emphasizes the followings: using FEM, we have obtained 17.37 MPa; using the photoelasticity method, we have obtained 16.9 MPa.
- The difference between these values (2.78%) confirms the good correlation of the results.
- These conclusions allow for the use of the finite element method as an optimization method for the geometry of the drill pipe upset end.



Influence of the Geometry of the DP Upset End upon the State of Stress

The investigations were carried out as follows:

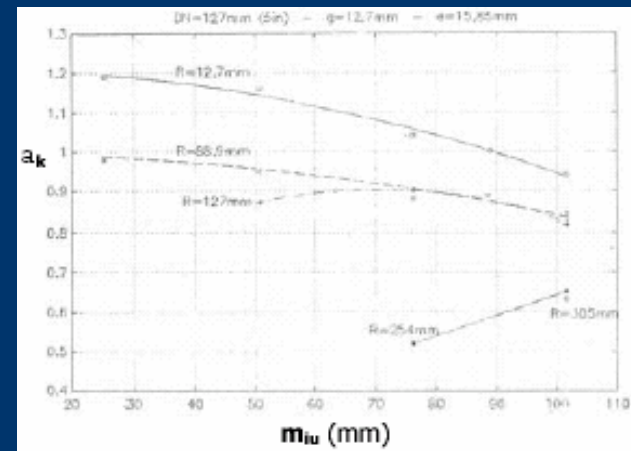
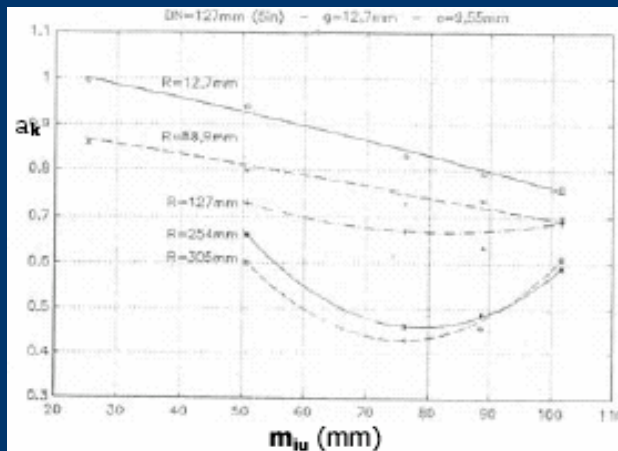
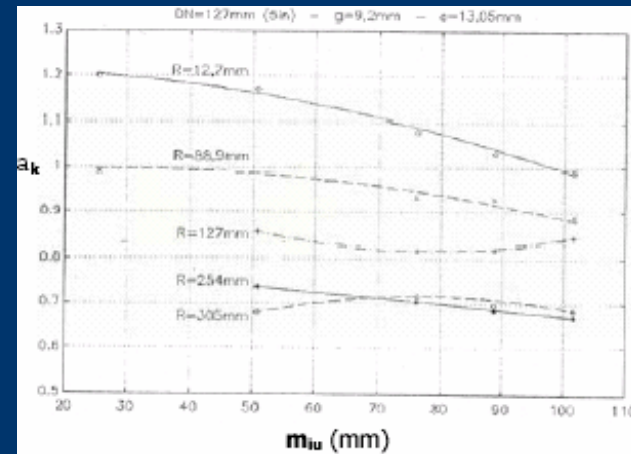
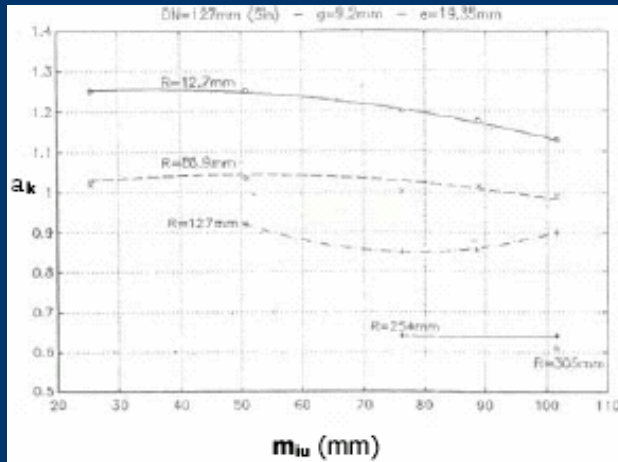
- the variation of the upset sizes, corresponding to the internal taper length, m_{iu} ;
- the variation of the connection radius, R , between the upset zone and the pipe body;
- the variation of the drill pipe steel grade, which implies the variation of the upset geometry.

The external stress concentration effect is less dangerous than the internal one, because the external upset zone is longer than the internal upset zone ($L_{iu} < L_{eu}$).



Influence of the Geometry of the DP Upset End upon the State of Stress

Dependence of the Stress Concentration Coefficient, a_k , versus the Taper Length, m_{iu}





Influence of the Geometry of the DP Upset End upon the State of Stress

For a given drill pipe connection combination, the internal (and external) stress concentration coefficients increase:

- with the decrease of the taper length (m_{eu} , m_{iu});
- with the decrease of the connection radius;
- with the increase of the e/g parameter, due to the increase of the steel grade of the drill pipe.

g – the thickness of the drill pipe body

$$e = 0.5(d - d_{ou})$$



Influence of the Geometry of the DP Upset End upon the State of Stress

- The stress concentration coefficient decreases when the connection radius increases, mainly for smaller values of R (under 100 mm);
- The stress concentration coefficient decreases when the length m_{iu} increases, if R is not greater than this length. If $R > m_{iu}$, practically m_{iu} has no influence.
- The stress concentration coefficient increases with the increase of the wall thickness in the upset zone. If $e/g > 2$, the concentration coefficient value is not influenced any more by the upset parameter.

If the connection radius exceeds the value of about 88.9 mm, the increase of the transition zone length over the minimum recommended API standards does not lead to a significant decrease of the stress concentration coefficient.



Correlation between the Drillpipe Upset Geometry and Its Fatigue Life Conclusions

1. According to the analysis method of the state of stress of drill pipes end upset zone (FEM), at for 5 in – IEU DP, an effect of stress concentration at the internal upset up to 1.25 appears, that initiates drill pipe breakdown in this zone.
2. A decrease of the stress concentration coefficient by 1.72 times could be obtained by increasing the connection radius from 12.7 mm to 305 mm for the same value of $m_{iu} = 88.9$ mm.
3. The stresses in the internal upset zone depend not only on m_{iu} and R but also on the configuration of the taper zone. The transition zone is not uniform and stresses could develop at greater values than those calculated based on certain values of m_{iu} and R.
4. The research was finalized issuing a design criterion for the geometry of the internal upset that leads to the migration of the breakdown starting point from the internal to the external part of the drill pipe.



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Quality Improvement of The Steels for the Drill Pipe Tool Joints – First Condition to Avoid Damages



Quality Improvement of the Steels for the Drill Pipe Tool Joints

- Drilling operations failures caused by the tool joints of the drill pipes have been registered. During the last 9 years, in Romania, a number of 195 pin tool joints and 15 box tool joints failures have been recorded.
- A large frequency of failures (87%) at the pin tool joints has been recorded in the winter period, after the drill pipes were tripped out from the hole and latched on the stand, at recorded temperatures between -18°C and -28°C .
- Researches performed by an interdisciplinary team established some conditions imposed mainly to the Romanian products, which resulted in the disappearance of such failures.
- Considering that these conditions should be included in API and ISO standards, we have announced the Romanian manufacturers and also the standardization organizations.



Quality Improvement of the Steels for the Drill Pipe Tool Joints

Proposed Conditions

1. Improvement of the quality of elaborated steels:
 - phosphorus content limited at max. 0.020%,
 - sulphur content limited at max. 0.015%,
 - gas contained after vacuum or R.E.Z.: H₂ – max. 3 ppm, O₂ – max. 60 ppm, N₂ – max. 80 ppm).
2. Imposed conditions for the toughness values:
 - at –20°C, KCU 300/2 longitudinal minimum 80 and transversal minimum 80;
 - at –30°C, KCU 300/2 longitudinal min. 55 – average 65 and transversal min. 30 – average 35.



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Thank you for your attention

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Expo Petro Gas & Energy
5-8 June 2007, Bucharest, Romexpo