YOUR TUBULAR STRING - KNOW ITS FIT FOR SERVICE WITH NDT TECHNIQUES

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ABSTRACT

In all successful tubular management programs NDT is used to know the real condition of pipe proposed for projects and to gain knowledge of used tubing at the wellsite. There are several testing methods available such as electromagnetic, ultrasonic, magnetic particle, eddy current and gamma-ray applied to various testing apparatus. There is an assumption made every day about new tubular products are defect free so know your material and its source, mill test reports are important to review. Used tubing in most wells is not inspected until a failure occurs. In many ways nondestructive testing is applied to help show the condition of new tubular products and to provide guidance on used tubing while pulling and in facilities for reclamation. NDT is directly associated to positive economics through extending the mean time between failures.

INTRODUCTION

When tubular materials are "New" different levels of NDT are used by the manufacturer to achieve specification requirements depending on pipe grade. NDT is also used to help control quality of the product for when process changes need to be measured and analyzed. For several reasons it is never safe to assume all new pipe is defect free, mainly in the seamless process inherently leaves imperfections in the tube body below reject levels. It's important to realize the actual pipe wall thickness is always thinner and thicker than specified wall. For example 2 7/8" x .217" wall x 6.50 #/ft x L-80 grade pipe API 5CT requires the mill to perform a visual inspection, wall thickness verification and one method or any combination of methods shall be used (UT EMI ET or MPI) in longitudinal orientation only for internal and external imperfections. The manufacturer's main focus is to detect defects greater than 12½% (.027" for .217") deep or wall thickness below 87 ½% of specified .217" (.190"). The actual pipe wall will be delivered above .190" on thin side of .217" to thicker side of .244" or greater only limited by outside diameter element. Knowing your pipe manufacturer and their quality program will close the gap on quality of pipe received for projects. Manufacturers are typically licensed to produce tubular products in accordance with manufacturing specifications like 5CT which control the dimensions and physical properties of their product as recorded in mill test reports.

INSPECTIONS

Nondestructive testing is used to identify and mitigated the unknown of new tubulars. Many defects are found when post mill inspections are performed and significant increases in risk exist when pipe is received without proper inspections. Ultrasonic testing is considered the best inspection method for measuring wall thicknesses and finding defect in thick wall products using a pulsed sound-wave traveling from the outer pipe surface to the inter pipe surface reporting the wall thickness within .002" of an inch accuracy. Very high-frequency sound waves are propagated into the pipe wall with acoustically water coupled transducers. UT body wall inspection incorporates a compression sound-wave measuring wall thickness and eccentricity. UT tube body inspection is very sensitive to internal flaws and their orientation with respect to the direction of the sound wave. The flaw must be with a few degrees of perpendicular to the sound-wave direction for a reflection to be received. Therefore, UT inspection systems require numerous transducers at various angles to cover as much of the pipe body as practical.

Electromagnetic inspection systems typically include four inspection services combined into one single pass of each tube: longitudinal flaw detection, transverse flaw detection, wall measurement - gamma ray, and a grade verification using eddy current. For internal and external flaw-detection methods, each tube is magnetized with either a

transverse or a longitudinal active magnetic field. Any magnetic flux leaking from an imperfection along the tube body will be deflected outside to the pipe's surface where coil elements are used to identify a potential flaw exist. Each pipe is traversed through a series of shoes containing coils designed to detect the diverted flux and to convert it into a voltage signal. This signal is amplified and filtered then recorded. If the magnitude of the deflection is greater than pre-set thresholds, the tube is marked for "prove-up" so it can be examined further and given a disposition per material specifications of API 5CT. The amount of any flux-leakage indication depends on a number of factors. The most significant are signal strength, magnetic field direction, flaw type, flaw orientation and its location.

Part of an EMI service is wall measurement using gamma ray technique, directing gamma radiation beams into the pipe wall, resulting in attenuation and measurement of the particle reflection. This system is used to detect eccentricity, wall reduction and other related wall defects with 2% calibration accuracy. The beam is rotated in a helical path showing percent of wall changes full length of tube body. A rarely used Eddy Current technique is focused on the surface detecting current anomalies when imperfections produce signal changes for new pipe inspections. The most widely used Magnetic Particle inspection is also a surface base inspection using residual magnetic with iron fillings spread over the magnetized area instantly showing flux leakage and the flaw outline. MPI in mainly used for the inspection of untested pipe ends where UT / EMI system are not able to cover.

Specific flaw types must be considered when achieving the highest quality inspection. Three dimensional type flaws (gouges, pits) and folded metal (laps, slivers) are best detected by the EMI method, tight seams and inside surface flaws are best detected by UT method, so it’s very important to realize how these inspection methods best complement each other in the same way as Longitudinal and Transverse complement each other in Magnetic Particle Inspection for untested pipe ends complimenting EMI/UT tube body inspection.

IN THE FIELD

Once the new tubular string is placed into service the classification changes to per API 5C1 on remaining wall thickness. The good tubing is above 85% remaining wall and identified by a yellow band, then down to 70% is a blue band, down to 50% is a green band and over 50% wall loss is a red band. Field inspection has been a great help to determine present string conditions allowing for better decision making and planning with known string factors. Onsite mobile inspection service while pulling tubing originated in mid-1980’s designed specific to inspect used API tubing sizes 2 3/8”, 2 7/8” and 3 1/2” from an oil, gas, injection or disposal well during work-over operations. This inspection service derived from the customer’s need for quick classification (snap shot) of tubing strings as they are being sequentially pulled building a well tubing profile. Many well characteristics are derived from the string condition data collected.

Field inspection at wellsite is focused on wall variations cause from in-service induced rod wear, erosion wear, and other general wall reductions from “like new” thickness. In conjunction to wall the EMI section detects cracks, corrosion pitting, holes and 3-Dimensional transverse type defects while the pipe is pulled from well displaying real time data on a CRT monitor in color coded graph (yellow blue green red). When pipe is identified as being suspect it is laid down from the rig by the crew for further investigation to determine actual classification. It’s important to know this service does not check connections or drifting.

The string must be laid down at wellsite to provide the best quality for proper cleaning and visual of connections identifying pitted threads and corroded leak paths. Also proper API recommended drift can be pulled full length verifying no mashes, dents or crushing in slip area exist.

INPLANT FACILITY

Used Tubular reclamation services are the most comprehensive economic choice when possible. Starts with Cleaning, for scale and paraffin, internally and externally, using our highly efficient, high-speed ID/OD cleaning system; Visual inspection, to inspect tubing to determine the extent of corrosion or physical damage and to reject those tubulars that are obviously unserviceable; Drifting, pulling cylinder full length of the tubing to identify

restrictions due to mashes, mechanical damage and to ensure it meets API or your own specifications; Electromagnetic inspection, performed on the tube body to detect service-induced flaws, such as corrosion pitting, cuts, gouges, cracks and rod wear; Connection inspection, performed on threads to catch defects in the end areas that an electromagnetic inspection cannot detect. This step also includes a critical examination of the upset area; Thread Compound, application of thread lube with either API-approved or customer specified, to protect the threads in storage and transit; Protectors, re-installing plastic pin-end thread protectors to connections protecting these vulnerable areas from damage during transit and storage; Marking, placing a stencil pertinent work order information onto each length of tubing; Tally, to measure tubulars verifying the number of good lengths ready for service or thread repair (when required); Segregate, to separate damaged tubulars by classification code (API5C1) or customer specifications, determining tubing inspected with reject footage; GOLD (global on line data), to track by computerized storage the inventory of your processed tubing using anytime access from internet showing recent activities.

Additional Service Options - Pressure test pipe, this is typically performed only on rethreaded tubing, using a positive pipe-securing method for enhanced safety; Straightening - Cross-roll**, t**o gently straighten bent tubing without causing further damage that can result in the loss of tubulars; Couplings, remove and reinstall couplings for 8rd connection where worn couplings are bucked off and new couplings bucked on to enable effective makeup when tubing is returned to service; Recut threads, damaged connections on good tubes which require machining prior to re-entering service; Thread protection, applying rust-preventive coating that will protect your tubing during storage, Handling, pick up and deliver tubing to ensure proper transport of your valuable tubular string.

ECONOMICS

When examining risk management of each well with the focus on cost several paths can be taken. First using the policy of replacing all the tubing with a new string will be the most expensive and may not be failsafe since uninspected new pipe could have defects causing unscheduled pulls. For cost example using a price of $6.20/ft or $192 average cost per length of new L-80 6.50 #/ft 8rd tubing, for a well with 290jts, out of pocket would be $55,738. It should be considered to add value performing post mill inspection with minimum cost providing possible huge savings by eliminating premature work-over cost. NDT is a useful tool providing a snap shot for extending tubing string life along with vendor evaluations.

At the wellsite, NDT continues to add value during a workover to confirm string condition relating to its position in the well. Tubing string profile from sequential inspection is real time looking for well deviations, erosion patterns, pitted areas, amount of reusable tubes and how many total lengths to be replaced. For example, if the above 290jts were re-inspected at 30 months of production and found 260jts are usable (yellow 0% - 15%) with 30 found to be laid down (26- blue / 3- green / 1- red) the savings for reusing 260 lengths would be $49,972 for not replacing re-inspected yellow bands and only additional cost of $5,766 to replace 30 lengths, adding inspection cost of $3,838 at wellsite still saves the well $40,368 on tubulars. Other savings not added is trucking/pulling rig time/lost production.

Tubing maintenance program, there is a continued savings when tubing strings are sent periodically into a facility for complete reclamation extending its life by taking a closer look at tube body, connections, internal plastic coatings and couplings while using refurbished Yellow band tubing for replacement strings.

For a greater example processing 5,117 lengths in a year to find 4,483jts are usable (yellow 0% - 15%) and 634 lengths were found to be classified as 503-blue / 79- green / 52- red the savings for reusing 4,483 yellow lengths would be $832,791. Real cost of $246,459 to inspect 5,117 lengths and replace 634 lengths showing a tubing program savings of over $586,332 for the year. Other savings not added is trucking/pulling rig time/lost production.

CONCLUSION

Post mill inspections of new tubulars help to remove defective lengths prior to running in well help you to know your string. Evaluation for actual wall thickness values knowing NDT is extremely important to the oil and gas

industry providing accurate and economical options of new pipe. Mill quality control departments highly depend on NDT to provide high speed coverage for hundreds of pipe processed each day. Especially for critical projects an engineer should specify tubular quality assurance inspections with a combination of methods such as EMI, UT and MPI on all surfaces and threaded connections.

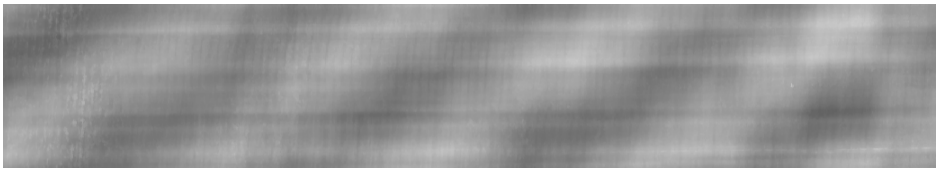
Field inspections used to identify which pipe is suitable for further service providing greater accuracy to classify pipes removing non fit tubes. Wellsite sequential inspections provide a snap shot for the present string condition and as important string profile showing where the conditions exist all while it's being pulled by workover rig. Electromagnetic flux leakage provides a very accurate process in detecting transverse orientation and three dimensional type flaws such as cracks, pitting and holes. The wall thickness measuring gauge has been specifically designed for rod wear, even-wear and corrosion / erosion conditions.

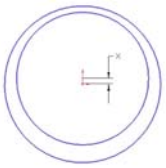
Plugging in the economic numbers really show how several options are available to best fit your risk management program in place especially when tied to a tubular management program tracking assets.

REFERENCES:

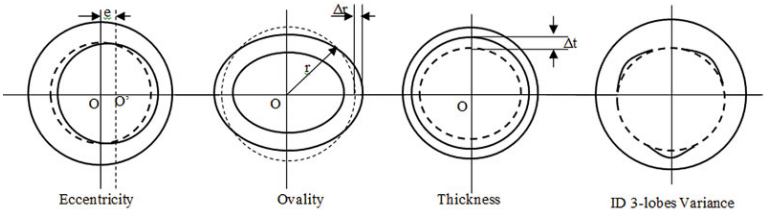
API Specification 5CT
API Recommended Practice 5C1
API Recommended Practice 5A5
Article Drilling Contractor 2013 Permanent production packer pushes limits Doane, Collins, Anderson, Shyu
Article World Oil 2004 225 7 pg41-48 Advanced OCTG topics for critical service Payne, Simpson, Livesay

New Pipe - Ultrasonic wall map showing wall thickness changes – full length tube body

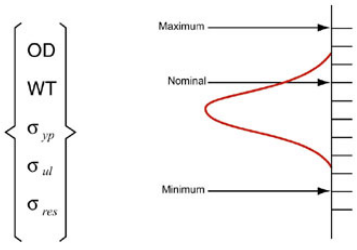




(lighter color is less than specified .217" wall thickness grey areas with black being greater than)



Various reasons why new pipe wall thicknesses are not exact



Typical API specification vs actual statistical variation

290 Lengths with Wellsite Inspection

Recovery Statistics:	Yellow Only				Lengths Summary
White	Wall Loss		%		
Yellow	Wall Loss	0-15	%		260
Blue	Wall Loss	15-30	%		26
Green	Wall Loss	31-50	%		3
Red	Wall Loss	51-100	%		1
				Total	290

COST OF NEW TUBING IF NOT REWORKED:					
290	Joints =	8,990	Feet @	$6.20	$55,738.00
SALVAGE SALE VALUE:					
290	Joints =	8,990	Feet @	$0.95	$8,540.50
NET NEW REPLACEMENT COST: (New Replacement Cost Less Salvage Value)					$47,197.50

ACTUAL COST OF INSPECTION:				re-use Yellow only	
Inspection, Rework Cost and Trucking (From Invoices)					$3,837.85
Replacement Cost of Reject Material:					
30	Joints =	930	Feet @	$6.20	$5,766.00
Salvage Credit for Rejects:					
30	Joints =	930	Feet @	$0.95	$883.50

SAVINGS:	
Net New Replacement Cost =	$47,197.50
Net Inspection & Replacement Cost =	$8,720.35
NET SAVINGS WITH INSPECTION	$38,477.15

5,117 Lengths with InPlant Services

Recovery Statistics:	Yellow Only				Lengths Summary
White	Wall Loss		%		
Yellow	Wall Loss	0-15	%		4,483
Blue	Wall Loss	15-30	%		503
Green	Wall Loss	31-50	%		79
Red	Wall Loss	51-100	%		52
				Total	5,117

COST OF NEW TUBING IF NOT REWORKED:						
5,117	Joints =	158,627	Feet @	$6.20	new price/ft	$983,487.40
SALVAGE SALE VALUE:						
5,117	Joints =	158,627	Feet @	$0.95		$150,695.65
NET NEW REPLACEMENT COST: (New Replacement Cost Less Salvage Value)						$832,791.75

SAVINGS:	
Net New Replacement Cost =	$832,791.75
Net Inspection & Replacement Cost =	$246,459.50
NET SAVINGS	$586,332.25

ACTUAL COST OF INSPECTION:				re-use Yellow only	
Inspection, Rework Cost and Trucking (From Invoices)					$143,276.00
Replacement Cost of Reject Material:					
634	Joints =	19,654	Feet @	$6.20	$121,854.80
Salvage Credit for Rejects:					
634	Joints =	19,654	Feet @	$0.95	$18,671.30
Net Inspection Cost & Reject Replacement Cost Less Salvage Value:					$246,459.50

Used Pipe - EMI inspection head on workover rig floor

In Service

Tubing Defects

Pitting

Rod Wear

Tubing Split

Mashed Coupling

Damaged Pins

Used Pipe - InPlant Inspection Services