Determination of Accelerated Iron Corrosion in Petroleum Products: A Comparative Study

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ABSTRACT

The muddled composition of some petroleum products contain elements that cause corrosion on interior surfaces, leading to the degeneration of pipelines and formation of detrimental deposits inside engines. The method used for analyzing the corrosive properties of gasoline and distillate fuels in preparation for transport through pipeline was originally developed by the National Association of Corrosion Engineers. The NACE TM0172 test method requires four hours to produce results and demands a 300 mL sample of the people in question. While in test method's success has served the industry well for many years, there has been a strong interest form all the key stakeholders for a quicker method with faster turnaround, smaller sample size and better repeatability and reliability.

Working really closely with key refineries around the country and executing numerous extensive laboratory trial and error experiments has all lead to a faster, easier, and more reliable test method. The new ASTM test method, ASTM D7548 for Determination of Accelerated Iron Corrosion in Petroleum Products is the evolution in state of the art laboratory corrosion measurement procedures. Its revolutionary characteristics touch upon some engineering concerns expressed by industry leaders regarding the accelerated corrosion test methods of the past.

The new method only requires a 50 mL sample and less than a fourth of time to complete testing in comparison to the NACE TM0172 and ASTM D665 accelerated corrosion test method . This less demanding laboratory setup will save the industry significant time when testing to determine the corrosive quality of various petroleum products. When applied to pipeline transfer station operations- where a quick QC turnaround time is absolutely critical-the ASTM D7548 test method becomes an adequate substitute for assurance.

Several trials were conducted to accurately test the effectiveness and quality of ASTM D7548 in comparison to the previous standard engineered by NACE. The setup is designed to reveal any biases between the two test methods and focuses on comparative attributes including variability precision, and indistinguishability. The associated data and results are discussed in the study.

OBJECTIVES

The main purpose of the Iron Corrosion Tests for Petroleum Products is to to eliminate or minimize damage due to corrosion. Water is usually a main factor for the corrosion; Corrosion caused by water can result in the following:

- Damaged Pipelines
- Deposits in Engines
- Damaged Storage Tanks and Facilities

ASTM test method D7548 developed by Imran Hussami of Frontier El Dorado Refining is an accelerated, user friendly version of NACE TM0172

NACE METHOD VS. ASTM D7548

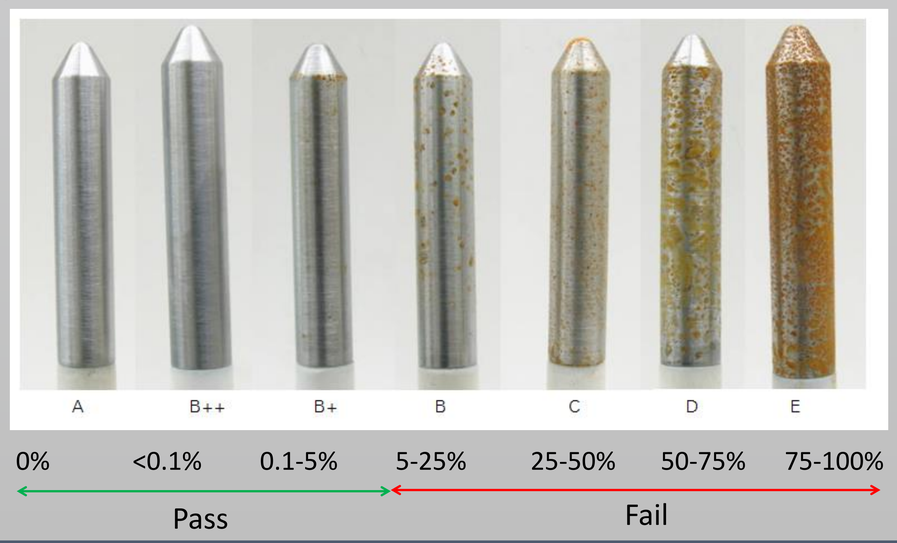
NACE TM0172

- 300 mL Sample Required
- 4 Hour Test Time
- 6 Sample Capacity
- Test bullets are polished so that surface is smooth

ASTM D7548

- 50 mL Sample Required
- 1.5 Hour Test Time
- 4 Sample Capacity
- 32 Test Results per Shift
- Test bullets are polished in circular grooves

The rod polishing method are used in both NACE TM0172 and ASTM D7548 that uses the specimen grading scale pictured below. This allows for results and data to be easily compared between both experiments.



COMPARATIVE ANALYSIS

Experiments have been completed by BP, Frontier El Dorado Refining Company, and Flint Hills Resources to determine if the Accelerated Test ASTM D7548 is a valid replacement for the original NACE TM0172.

BP Laboratory Experiment

The BP Experiment was set up in the following manner and the purpose of the experiment was to look at bias between the tests (AICT and NACE), variability / precision, and indistinguishability.

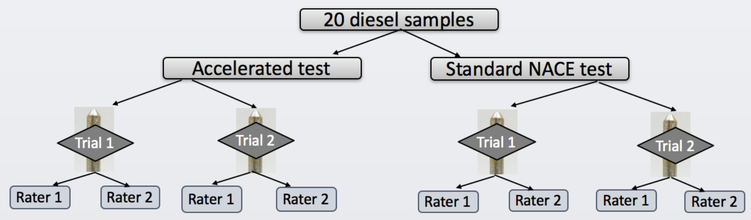


Figure 1: BP Experimental design

Table 1: Test results of Fuel Samples Using NACE and ASTM methods

FUEL	RATING	
	AICT	NACE
ULSD 1	A	A
ULSD 1 (duplicate)	A	A
ULSD 2 (CARB) - untreated	B	C
ULSD 3 - unfiltered (9/21/11)	C	C
ULSD 3 + 1.5 ppm CI#1	B	B
ULSD 3 + 1.5 ppm CI#3	B	B
ULSD 3 + 1.5 ppm CI#4	B	B
ULSD 3 - unfiltered (2/24/12)	A	B++
"Renewable" Diesel - untreated	B	B
ULSD 4 untreated	D	D
ULSD 4 + 3 ppm CI#1	B+	A
ULSD 4 + 3 ppm CI#2	B++	A
ULSD 4 + 3 ppm CI#3	A	A
ULSD 4 + 3 ppm CI#4	B	B+
ULSD 5 untreated	C	C
ULSD 5 + 3 ppm CI#1	B++	B++
ULSD 5 + 3 ppm CI#2	B+	B++
ULSD 5 + 3 ppm CI#3	A	A
ULSD 5 + 3 ppm CI#4	B	B+

By using the BP Experiment shown above , the following conclusions can be made:

- **Bias:** There is no bias between methods – paired t-test (p = 0.8345)
- **Precision / Variability:** Both tests have same precision – 75% agreement within each test
- **Indistinguishable:** The tests are not indistinguishable – 53% agreement between tests
- **Rater Agreement:** Excellent agreement between readers – 93.75% or 75 out of 80 test rods

ASTM Ruggedness Study

ASTM Ruggedness Studies are used to pinpoint variables associated with performance of the test method before running a full Interlaboratory Study (ILS) to determine the precision statement section of the standard test method. For this test, samples of Gasoline, Jet Fuel, and Ultra-Low Sulfur Diesel (ULSD) were used.

- 95mL of each sample with an initial corrosion rating of E was supplied
- 5mL of corrosion inhibitor of required volumes were supplied to get the sample to the target rating

Table 2: Ruggedness Study: Determination of AICT test in Petroleum Products

RUGGEDNESS STUDY
DETERMINATION OF ACCELERATED IRON CORROSION IN PETROLEUM PRODUCTS - ASTM STM D7548-09

LAB. NO:-	L1			L2			L3		
	CR	%	TESTED	CR	%	TESTED	CR	%	TESTED
SAMPLE									
GASOLINE	(Sampled: 3/26/2015 - 64Tk)								
GA	B+	1	5/20/2015	B	20	5/28/2015	C	40	6/17/2015
GB+	B+	3	5/20/2015	B	20	29-May	D	60	17-Jun
GB+	B	5	5/20/2015	C	40	30-May	C	35	16-Jun
GB	B+	3	5/20/2015	C	25	29-May	B+	2	16-Jun
GB	C	40	5/20/2015	C	40	29-May	D	60	16-Jun
GE	E	98	5/20/2015	E	100	28-May	B+	4	16-Jun
JET FUEL	(Sampled: 11/25/2014 - 75Tk. Kept in Cold Chamber. Taken 4L on 4/16/15)								
JA	B++	<0.1	5/20/2015	A	0	30-May	D	50	16-Jun
JB+	B++	<0.1	5/20/2015	A	0	28-May	C	40	16-Jun
JB+	A	0	5/20/2015	B++	<0.1	28-May	B+	2	16-Jun
JB	B+	4	5/20/2015	A	0	28-May	D	55	17-Jun
JB	B+	3	5/20/2015	B+	<5	29-May	B+	2	17-Jun
JE	D	70	5/20/2015	E	75	28-May	B+	2	17-Jun
ULSD	(Sampled: 5/19/2015 - 24Tk)								
UA	B+	4	5/20/2015	A	0	6/4/2015	B+	4	6/16/2015
UB+	B	10	5/20/2015	B+	<5	30-May	B	8	16-Jun
UB+	B	20	5/20/2015	B	10	28-May	B	15	16-Jun
UB	C	33	5/20/2015	D	50	30-May	C	30	16-Jun
UB	C	35	5/20/2015	B	10	28-May	C	40	16-Jun
UE	E	90	5/20/2015	E	75	4-Jun	C	28	17-Jun

CORROSION RATINGS: A = 0%; B++ = <0.1%; B+ = <5%; B = 5-25%; C = 25-50%; D = 50-75%; E = 75-100%
SAMPLES PREPARED - FOR L1: on 5/19/15; FOR L2 and L3: on 5/20/15

The results of the test performed during the ASTM Ruggedness Study shown above are within the acceptable level of one corrosion rating of each other. Wider differences are due to under or over performance of the corrosion inhibitor which will have to be more accurately monitored during the ILS.

CONCLUSIONS

The Accelerated Iron Corrosion Test Method, ASTM D7548, successfully captures the corrosion level of the samples involved at the time of test. Due to no bias and same precision, ASTM D7548 is a valid replacement of the original NACE TM0172 Test Method.

FUTURE WORK

- Analyzing different types of fuels, other than those specified in the Scope of D7548.

REFERENCES

1. **NACE Standard TM0172-2001** "Determining Corrosive Properties of Cargoes in Petroleum Product Pipelines" (Houston, TX: NACE International).
2. **ASTM D7548-2009** "Standard Test Method for Determination of Accelerated Iron Corrosion in Petroleum Products" (West Conshohocken, PA: ASTM International).
3. **BP Global Fuels Technology** "Assessing the Equivalence of the ASTM D7548-09 Accelerated Iron Corrosion Test and the Standard NACE TM-0172 Test Using Diesel Fuels" ASTM June 2013 Meeting. PowerPoint Presentation.
4. **Original Work – Imran Hussami** "Comparative Tests – 1h AICT vs. 4h NACE" Done at Frontier El Dorado Refining Company and Flint Hills Resources, 2008.

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