



an EnPro Industries company

Isolation Testing of Hardened Coated Steel (HCS) Washers

Date of Test: November 7, 2008

Product Tested: 6" inch Class 300 VCS Isolating Gasket with HCS washers with 2 applications of Dielectric coating (1-1.5 mil thickness per layer).

Purpose of Test: The test was conducted to determine the ability of the HCS washer coating to maintain electrical isolation of the flanges during multiple bolt-ups. The test was also performed to investigate the ability of one (1) HCS coated washer per nut to maintain electrical isolation.

Test Procedure: 6" Class 300# ASME B16.5 carbon steel flanges with a bore diameter of 6" was used for the testing. The flanges were bolted together with (12) studs and (24) nuts Grade A193-B7. Every third nut was purposely installed with the incorrect face against the washers to better simulate field circumstances.

Test series 1: Using a VCS 6" 300, G-10 sleeves, and two HCS washers per nut, the flange assembly was bolted-up to 150ft-lbs of torque and the flange to flange and bolt to flange isolation/resistance was measured. The assembly was then unbolted. The same procedure was then repeated for a second and a third bolt-up. During this test series the flange was painted.

Test series 2: Similarly to test series 1 a VCS 6" 300, G-10 sleeves were used however, only with **1 HCS washer per nut**. The flange assembly was bolted-up to 150ft-lbs of torque and the flange to flange and bolt to flange isolation/resistance were measured. The assembly was then unbolted. The same procedure was then repeated for a second and a third bolt-up. During this test series the flange paint was removed to decrease isolation that was not associated directly with the washers.

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A Megger[®] Insulation Tester was used to measure resistance/isolation from Flange to flange and Bolt to Flange. The highest voltage setting of 1000V was used.

Conclusion:

Isolation Test for Test Series 1:

- The Flange to Flange isolation properties remained at 200 GOhms during all three bolt-ups.
- The Flange to Bolt isolation properties remained at 200 GOhms during all three bolt-ups.

Isolation Test for Test Series 2:

- The Flange to Flange isolation properties were the following:
 - Bolt-up #1 - 70 GOhms
 - Bolt-up #2 - 40 GOhms
 - Bolt-up #3 - 20.3 MOhms
- The Flange to Bolt isolation properties were the following (Average of 4 readings):
 - Bolt-up #1 - 158 GOhms
 - Bolt-up #2 - 153 GOhms
 - Bolt-up #3 - 81.8 GOhms

Conclusion: Dual HCS washers maintain very high levels of insulating even after multiple bolt-ups. Since the general industry practice is to require a minimum value of 2-3 MOhms resistance for insulating gasket assemblies, a single HCS washer per nut will provide more than sufficient electrical resistance for insulating gasket assemblies. However, this configuration is not recommended due to isolation degradation seen in subsequent bolt-ups.

Test Witnesses:

David Wittekind, Pikotek Engineer

Ben Kramer, Engineering Manager

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Summary

Pikotek has had customers express interest in the durability of the coating on the Hardened Coated Steel washers and if they are re-usable after undergoing a bolt-up. Two 6" Class 300# ASME B16.5 carbon steel flanges were used to perform flange isolation tests using the same coated washers to perform multiple bolt-ups of the flanges. A test was also performed to determine if only one washer could be used per nut instead of the (2) currently required.

The objective in the testing was to verify the isolation of flanges after multiple bolt-ups of the flanges. The results of the testing demonstrate that when two (2) washer are utilized that the washers can be used for at least (3) consecutive bolt-ups without compromising the electrical isolation of the flange connection.

When one (1) washer is utilized per nut, after 3 bolt-ups the electrical isolation is maintained above the 2-3 MOhms requirement but at substantially lower levels than seen during the initial bolt-up. While maintaining very good electrical resistance in the initial bolt up, the single washer configuration is not recommended as during subsequent bolt-ups the coating is degraded and does not maintain the electrical isolation levels seen with the dual bolt configuration.

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Introduction

The test assembly consisted of the following:

- 6” Class 300# ASME B16.5 carbon steel flanges with a bore diameter of 6”
- (12) Threaded stud bolts and (24) nuts, A193 Grade B7 and A194 - Grade 2H respectively.
- (1) 6” Class 300# Pikotek VCS isolation gasket
- (12) G-10 isolating sleeves
- (72) Hardened Coated Steel (HCS) washers, 48 for test series 1 and 24 for test series 2

The Pikotek VCS gasket was installed between the flanges and the flanged assembly was made up with a torque value of ~150ft-lbs using a standard torque wrench. After the gasket, sleeves, and washers were assembled in the test set-up, a Megger® insulation tester (model 481) was used to validate the gasket’s isolation properties. The device was set to the highest voltage position of 1000V DC and applied to one side of the flanged connection. Using the same setting, the voltage was then applied to four bolts, 1 located on each quadrant of the flange. The outputs of both tests were measured on the opposing flange as resistance in Ohms.

During the first test series where 2 washers per side were used, the portion of the flange that comes into contact with the washers was coated in thin layer of paint. This layer of paint likely added to the resistance values being measured. To be as conservative as possible the painted was removed during test series 2 when only one washer per side was used. **(Figure 9)**

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Test Procedure

Below is a summary of washer isolation testing that was performed on the HCS washers:

Test series 1

1. Install Pikotek VCS isolation gasket between the flanges using isolating sleeves and 2 HCS washer per side. Torque the nuts on the assembly to 150ft-lbs.
2. Use the Megger insulation tester set at 1000V DC and test isolation flange-to-flange and flange-to-bolt (flange to bolt measurements to be taken on each quadrant of the flange and the averaged).
3. Unbolt the assembly and make sure all of the washers are loose and not stuck to either the flanges or to a nut.
4. Repeat steps 1-3 two more times
5. Inspect the washers on both sides

See **Figures 1-5** for test procedure photos

Test series 2

1. Remove paint from the flange where the washers come into contact. **(Figure 9)**
2. Install Pikotek VCS isolation gasket between the flanges using isolating sleeves and 1 HCS washer per side. Torque the nuts on the assembly to 150ft-lbs.
3. Use the Megger insulation tester set at 1000V DC and test isolation flange-to-flange and flange-to-bolt (flange to bolt measurements to be taken on each quadrant of the flange and the averaged).
4. Unbolt the assembly and make sure all of the washers are loose and not stuck to either the flanges or to a nut.
5. Repeat steps 1-3 two more times
6. Inspect the washers on both sides

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Results

Test Series 1:

**1000V DC with flange Paint ---All values are in Ohms (Ω) ---*

	Bolt-up #1	Bolt-up #2	Bolt-up #3
Flange to Flange	200 GOhm	200 GOhm	200 GOhm
Flange to Bolt #1	200 GOhm	200 GOhm	200 GOhm
Flange to Bolt #2	200 GOhm	200 GOhm	200 GOhm
Flange to Bolt #3	200 GOhm	200 GOhm	200 GOhm
Flange to Bolt #4	200 GOhm	200 GOhm	200 GOhm
Flange to Bolt Average (4 measurements)	200 GOhm	200 GOhm	200 GOhm

Test Series 2:

**1000V DC no flange Paint ---All values are in Ohms (Ω) ---*

	Bolt-up #1	Bolt-up #2	Bolt-up #3
Flange to Flange	70 GOhm	40 GOhm	20.3 MOhm
Flange to Bolt #1	80 GOhm	60 GOhm	0.01 MOhm
Flange to Bolt #2	200 GOhm	200 GOhm	27 GOhm
Flange to Bolt #3	150 GOhm	150 GOhm	200 GOhm
Flange to Bolt #4	200 GOhm	200 GOhm	100 GOhm
Flange to Bolt Average (4 measurements)	158 GOhm	153 GOhm	81.8 GOhm

After completion of both test series, the flange halves were disassembled and the washers were inspected and photographed. **(Figures 6-8)**

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Conclusion

The objective in the testing was to verify the isolation of flanges after multiple bolt-ups of the flanges while still using the same set of HCS washers. The results of the testing demonstrate that when two (2) washers are utilized that the washers can be involved in (3) bolt-ups without any degradation of the electrical isolation of the flange connection. In fact, the results show no difference between the 1st and the 3rd bolt-ups. Thus, when (2) HCS washer are utilized, 3 separate bolt-ups did not compromise the isolation of the flanges.

During test series 2, the objective was to see if one (1) HCS washer per nut could maintain flange isolation. The results show that for one bolt-up isolation of the flanges is above the required limit but below the value seen with (2) HCS washer. During the second bolt-up the isolation value between the flanges decreased a little but the bolt-to-flange measurements began to drop. During the third bolt-up the isolation measurements dropped even further and even had a measurement of almost no isolation for one bolt-flange measurement. Furthermore, the likelihood that the coating would be further compromised at higher torque levels indicates the electrical isolation is only maintained for the initial bolt-up. During subsequent bolt-ups the coating is damaged enough to degrade the electrical isolation properties of the flange connection.

If used accidentally the single HCS washers will maintain more than sufficient electrical isolation but this isolation will certainly degrade with subsequent bolt-ups.

Recommendation

Two HCS washers per nut is the recommended configuration. If single HCS washers are utilized it is further recommended that they not be reused and instead be discarded after a single use.

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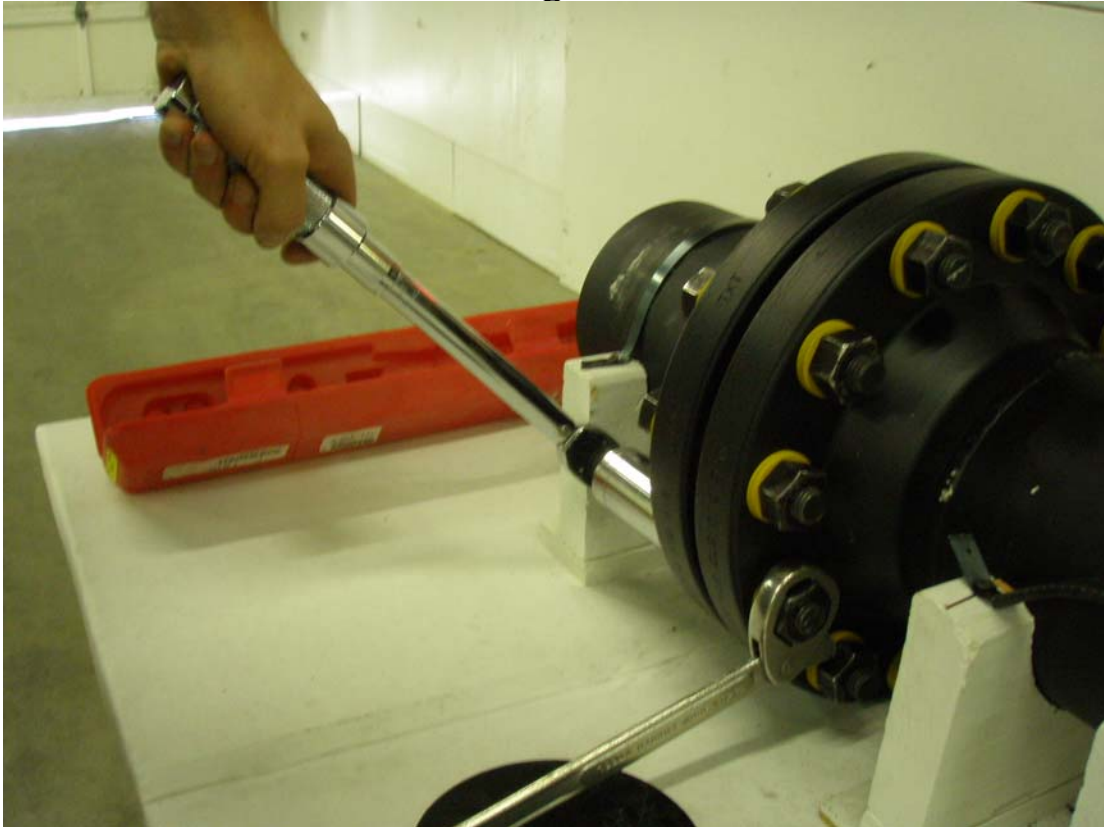


Figure 1 – Torque Being Applied



Figure 2 – Close-up of two HCS washers

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Figure 3 – Impact wrench used to unbolt the flanges

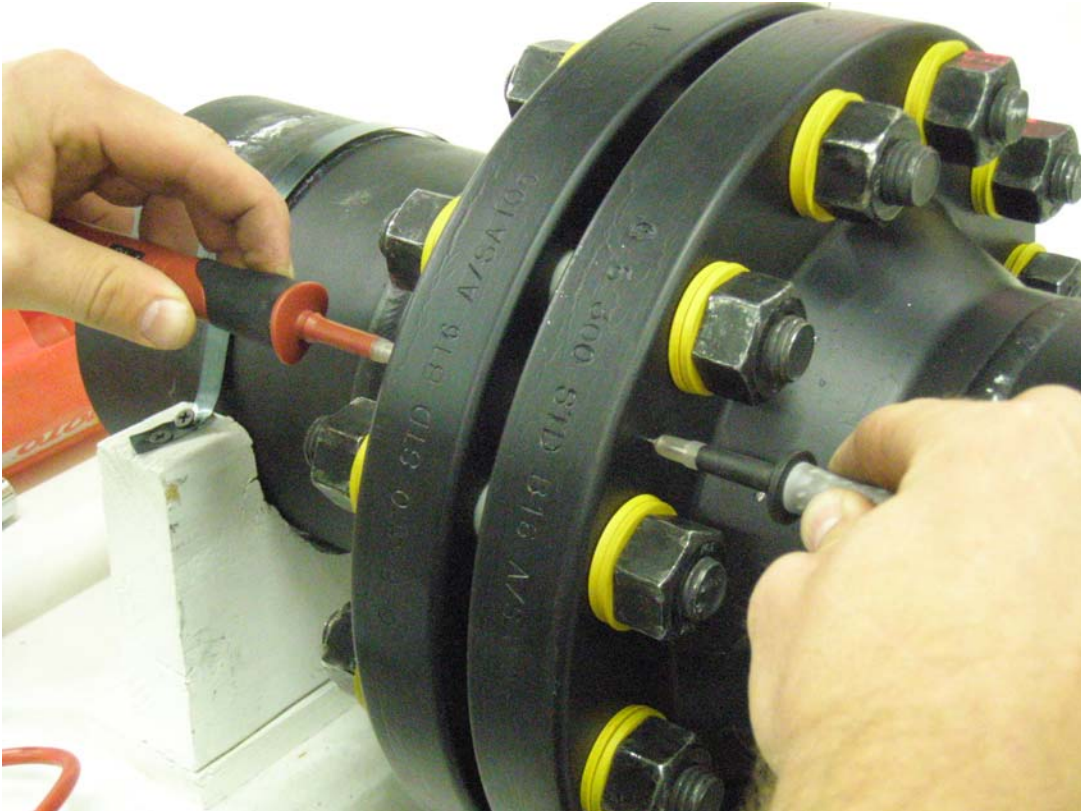


Figure 4 – A flange-to-flange measurement being taken

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Figure 5 – The resultant measurement of figure 4



Figure 6 – Test Series 1 Post 3rd Bolt-up Washer-Nut Faces

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Figure 7 – Test Series 1 Post 3rd Bolt-up Washer-Washer Faces



Figure 8 – Test Series 1 Post 3rd Bolt-up Washer-Flange Faces

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Figure 9 – *Test Series 2* Paint removed from flange