

**Colt Atlantic Services, Inc.**

**Power Services Division**

SF-6 Gas Leak Reduction Using Under  
Pressure Leak Sealing

# Industry Start

- Repairing steam leaks to keep ships moving during WWII.
- Also allowed manufacturing facilities to be more productive.
- Power generation was maintained by making repairs without shutting down.



# Before & After



# The Repair Process

- Determine point of leak.
- Technician takes precise measurements for a containment device.
- Engineer designs a clamp or enclosure.
- Clamp/enclosure is bolted around the leak and hydraulically injected with sealant.



# Clamp/Enclosure Engineering

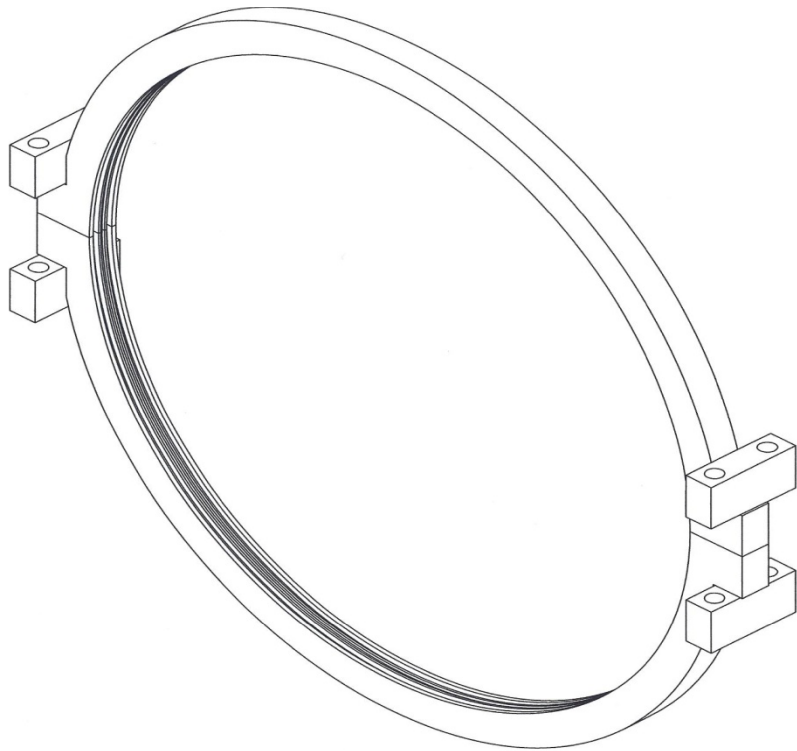
**\*\*DEVICE FABRICATION & CALCULATION PACKAGE CHECKLIST\*\***  
 (CHECK MARKS AND N/A ARE THE ONLY OPTIONS)

<b>DRAWING</b>	<b>CHECK</b>
Each component fully dimensioned where shown.....	✓
Studs defined and described.....	✓
Shell thickness.....	✓
Corrosion allowance.....	N/A
Ear width, height, holes.....	✓
Number (& location) of injection fittings.....	✓
Mating (to host) surface features.....	✓
Detail allows fabrication (& Cal's) without other ref.....	✓
Weld details defined and supported.....	N/A
<b>CALCULATIONS</b>	
Conceptual (Isometric) exists, and is accurate.....	✓
Index describes location of key calculations.....	✓
Client parameter are defined, (and adequate).....	✓
Stresses at all key points.....	✓
Maximum allowable pressure (and limiting component).....	✓
Strongbacking.....	N/A
Welds (& strengths) fully defined.....	N/A
Complete bill of materials.....	✓
<b>TESTING</b>	
Dye check.....	N/A
Hydrostatic pressure.....	N/A
Other.....	N/A

*Signature*

**CALCULATIONS BY** \_\_\_\_\_  
**DATE**     2/26/09

**CHECKED BY**                    **PG** \_\_\_\_\_  
**DATE**     2/26/09



**PROPRIETARY AND CONFIDENTIAL**  
 THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF THE COLT GROUP. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF THE COLT GROUP IS PROHIBITED.

		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±
		MATERIAL SEE BOM
NEXT ASSY	USED ON	PROJECT CA19926-731
APPLICATION		DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	GAM	2/26/2009
CHECKED	QL	2/26/2009
ENG APPR.		
MFG APPR.		
Q.A.		

DESIGNED FOR DUPONT BELLE		
<b>56 3/4" O.D. EXCHANGER CLAMP</b>		
SIZE <b>A</b>	DWG. NO. CA19926-731	REV.
SCALE: 1:16	WEIGHT:	SHEET 2 OF 9



PHONE (281) 471-9099

CLIENT: DUPONT BELLE

JOB #: CA19926-731  
DESIGN #: Q020923

COLT SERVICES LP

-----  
I N D E X   O F   P A G E S  
-----

Checklist.....1

Conceptual Drawing.....2

Index.....3

Design Parameters..(Applicable Exemptions, if any).....4

Calculation Summary.....4

All Stresses.....5

Maximum Allowable Pressure.....6

Bill of Materials.....7

Sealant Volume.....7

Weights.....7

Fabrication Drawings.....8 thru 9

Calculations by  on 2/26/09

Checked by PG on 2/26/09

CLIENT: DUPONT BELLE

JOB #: CA19926-731  
DESIGN #: Q020923

COLT SERVICES LP

SUMMARY OF THE CALCULATIONS

DESIGN PRESSURE = 200 psig  
DESIGN TEMPERATURE = 338 deg f  
SERVICE = Amine

THIS DEVICE WILL SUSTAIN MAXIMUM DESIGN PRESSURE OF 453.50 PSI

This clamp is made from SA-516/675 Gr 70 plate and held together by studs of SA-193 Gr B7 & SA-194 Gr 2H nuts.

The injection pressure of 260 psi is derived from the design pressure, it is the pressure differential (required at the gage) to overcome the design pressure, which is assumed to be in the device after attachment, and this higher pressure is used throughout calculations.

All formulae are from ASME Sect. VIII Div. I or ROARK'S 'Formulas for Stress and Strain.'

The stress in the clamp shell is 2673.02 psi vs the allowed 22196 psi.

The studs (worst case) are stressed at 14332.88 psi vs their 25000 psi allowed.

The stress in the plate ears are 1839.67 psi vs their allowed 22196 psi.

The installed unit will weigh about 560.0 #.

Calculations by  on 2/26/09

Checked by PG on 2/26/09



CLIENT: DUPONT BELLE

JOB #: CA19926-731  
DESIGN #: Q020923

COLT SERVICES LP

-----  
CALCULATION OF STRESSES  
-----

For stress in the clamp shell;

where Pi = injection pressure = 260  
R = inner radius = 28.44  
t = shell thickness = 2.94

$$S = \frac{Pi(R+.6t)}{t} = 2673.02 \text{ psi}$$

vs the allowed 22196 psi

The stress in the retaining studs due to pressure is;

where F = Pi \* Ap = 18486.0  
Ap = pressure area = 71.1  
Nb = number of studs = 4  
Ab = area of each = 0.929

$$S = \frac{F}{Nb * Ab} = 4974.70 \text{ psi}$$

vs the allowed 25000 psi

For the plate ears stresses;

where F = (Pi \* Ap)/2 = 9321.0  
Ap = pressure area = 71.7  
l = effective beam = 5.00  
b = = 2.38  
d = = 4.00  
Z = section modulus = 6.33  
(b \* d^2) / 6

$$S = \frac{F * l}{4 * Z} = 1839.67 \text{ psi}$$

vs the allowed 22196 psi

The stress in the existing exchanger studs due to pressure is;

where F = Pi \* Ap = 639132.0  
Ap = pressure area = 2458.2  
Nb = number of studs = 48  
Ab = area of each = 0.929

$$S = \frac{F}{Nb * Ab} = 14332.88 \text{ psi}$$

vs the allowed 25000 psi

CLIENT: DUPONT BELLE

JOB #: CA19926-731  
DESIGN #: Q020923

COLT SERVICES LP

B I L L O F M A T E R I A L			
ITEM	QTY	DESCRIPTION	MATERIALS
1	1	CLAMP 2 1/2" THK. * 62 3/4" O.D.	SA-516/675 Gr 70
2	4	BARS 2 3/8" THK. * 4" * 8" LONG	SA-516/675 Gr 70
3	40	STANDARD INJECTORS	SA-240 Gr 316
4	4	STUDS 1 1/4-8 * 20" LONG	SA-193 Gr B7
5	8	NUTS 1 1/4-8 HEX	SA-194 Gr 2H
6	50.0 #	SEALANT	

W E I G H T S

CLAMP	480.0 #
STUDS & NUTS	30.0 #
SEALANT	50.0 #
TOTAL	560.0 #

CLIENT: DUPONT BELLE

JOB #: CA19926-731  
DESIGN #: Q020923

COLT SERVICES LP

-----  
M A X I M U M A L L O W A B L E P R E S S U R E  
-----

The maximum allowable design pressure for this clamp;

For the clamp shell;

$$\frac{S_a * t}{(R + .6 * t)} = 2158.97 \text{ psi}$$

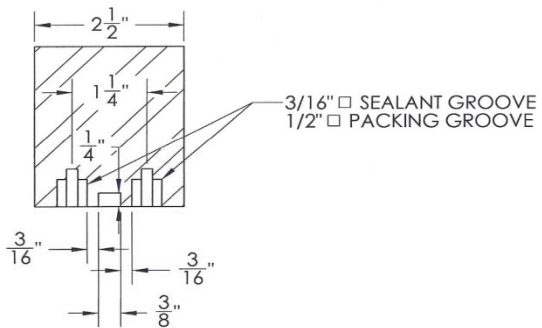
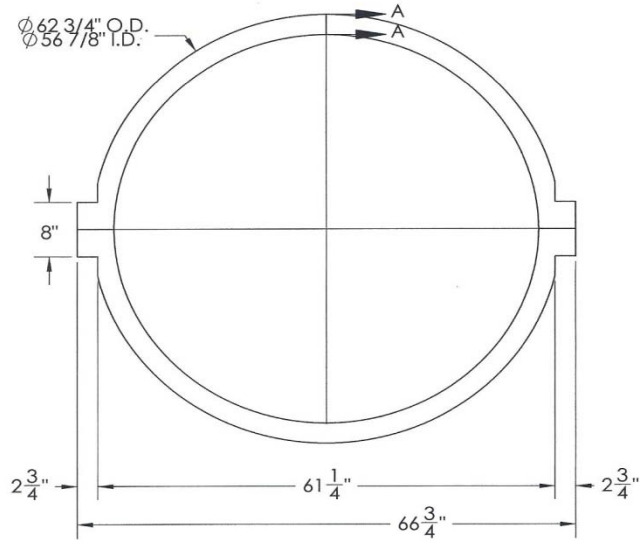
For the studs;  
(worst case)

$$\frac{S_a * N_b * A_b}{A_p} = 453.50 \text{ psi}$$

For the plate ears:

$$\frac{S_a * 8 * Z}{1 * A_p} = 3136.95 \text{ psi}$$

-----  
For this device ( EXISTING EXCHANGER STUDS LIMIT ) = 453.50 psi  
=====

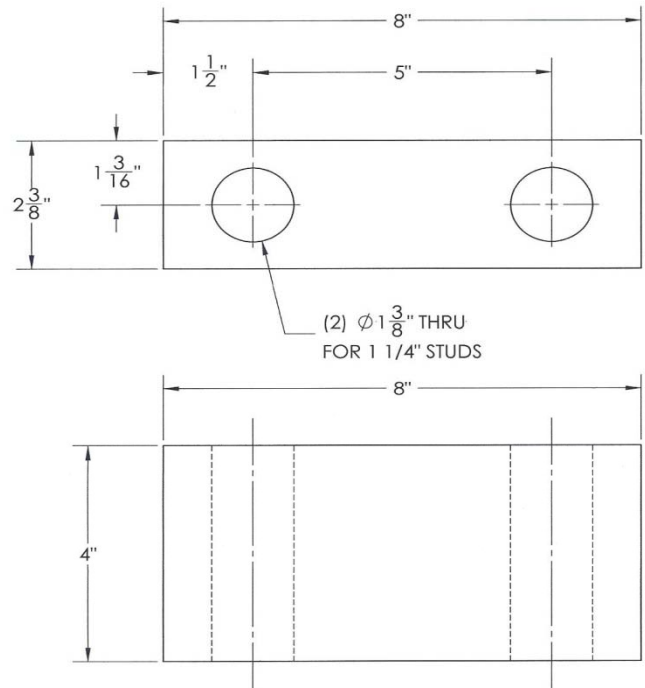


**INJECTION POINTS**

GROOVES	(24)
CAVITY	(16)
<b>TOTAL</b>	<b>(40)</b>

**PROPRIETARY AND CONFIDENTIAL**  
 THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF THE COLT GROUP. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF THE COLT GROUP IS PROHIBITED.

DIMENSIONS ARE IN INCHES		NAME	DATE	<b>DESIGNED FOR DUPONT BELLE</b>	
TOLERANCES:		DRAWN	GAM		2/26/2009
FRACTIONAL ±		CHECKED	GL		2/26/2009
ANGULAR: MACH ± BEND ±		ENG APPR.			
TWO PLACE DECIMAL ±		MFG APPR.			
THREE PLACE DECIMAL ±		Q.A.			
MATERIAL		SEE BOM			
NEXT ASSY	USED ON	PROJECT	CA19926-731	<b>56 3/4" O.D. EXCHANGER CLAMP</b>	
APPLICATION	DO NOT SCALE DRAWING				
		<b>COLT SERVICES LP</b>		SIZE <b>A</b>	
		PHONE (281) 471-9099		DWG. NO. <b>CA19926-731</b>	
				SCALE: 1:16   WEIGHT: 376   SHEET 8 OF 9	



(2)  $\phi 1 \frac{3}{8}$ " THRU  
FOR 1 1/4" STUDS

**NOTE:**  
**MAKE 4 IDENTICAL BARS**

<b>PROPRIETARY AND CONFIDENTIAL</b> THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF THE COLT GROUP. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF THE COLT GROUP IS PROHIBITED.		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±		NAME G.A.M.	DATE 2/26/2009	DESIGNED FOR DUPONT BELLE  <b>56 3/4" O.D. EXCHANGER CLAMP</b>
		MATERIAL SEE BOM		CHECKED Q.L.	DATE 2/26/2009	
PROJECT CA19926-731	NEXT ASSY USED ON	APPLICATION DO NOT SCALE DRAWING			DWG. NO. CA19926-731	REV.
PHONE (281) 471-9099		SCALE: 1:14			WEIGHT: 18	SHEET 9 OF 9



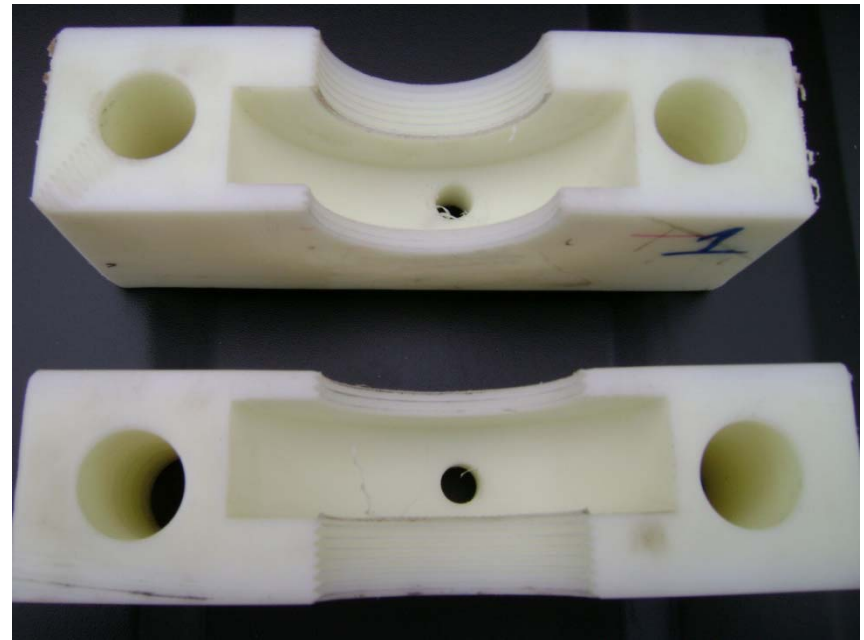
## Typical Custom Flange Clamp

Manufactured from Aluminum, Cast Nylon or Carbon depending upon the application.

# Cast Nylon-SF6 Gas Leak Enclosure

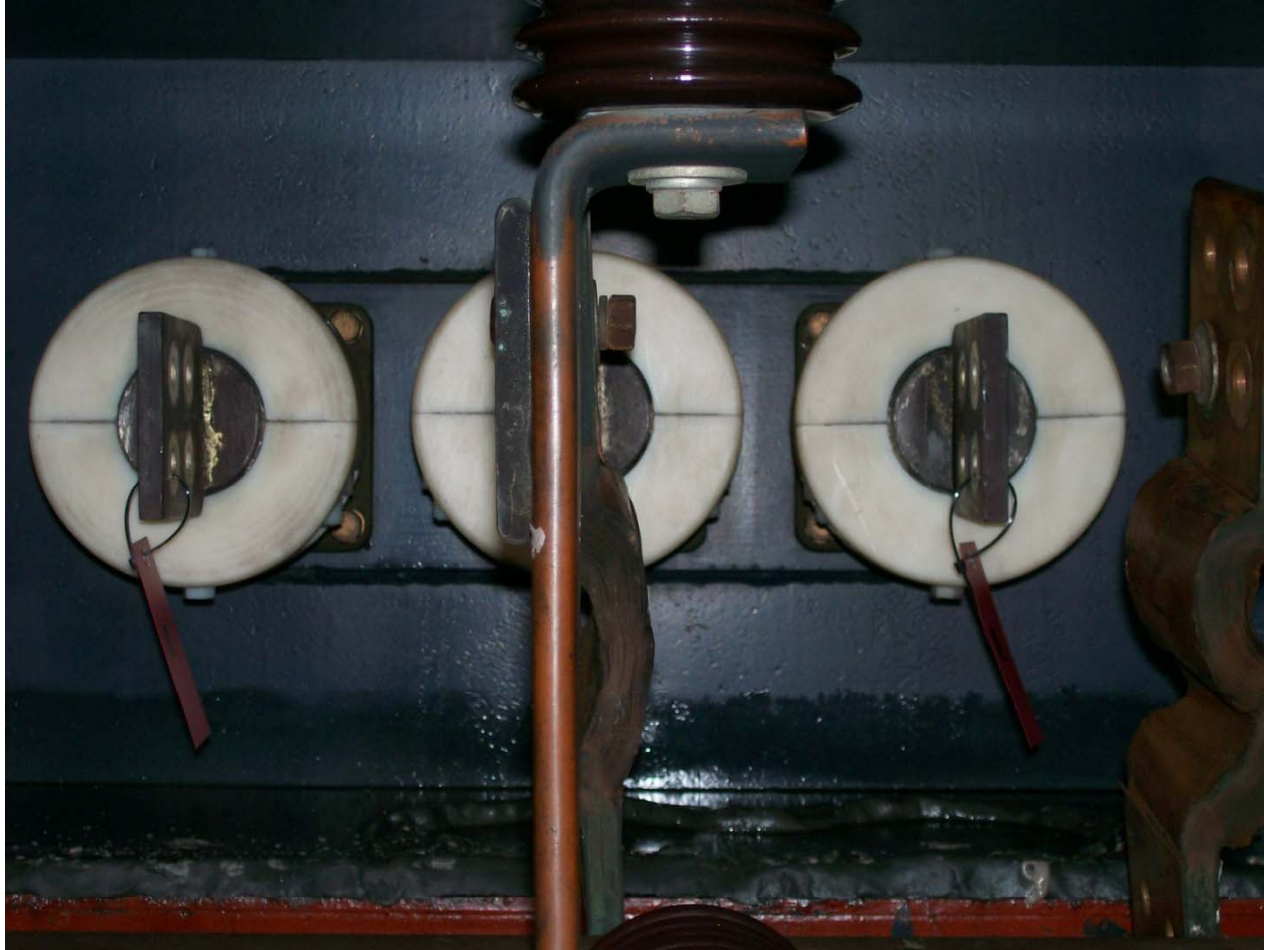


# Various Applications





# Cast Nylon Clamps

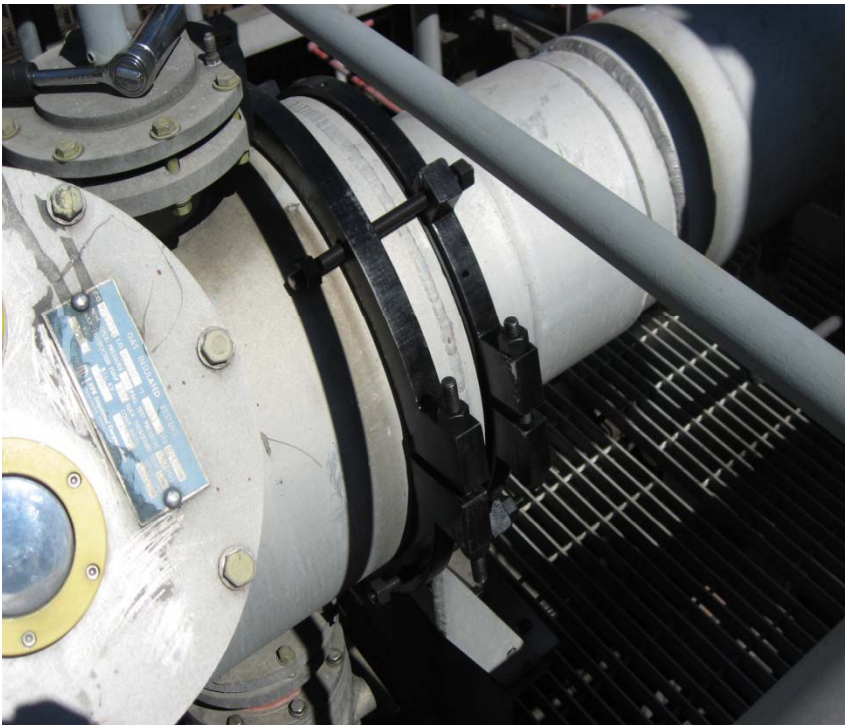


# Aluminum Flange Clamps

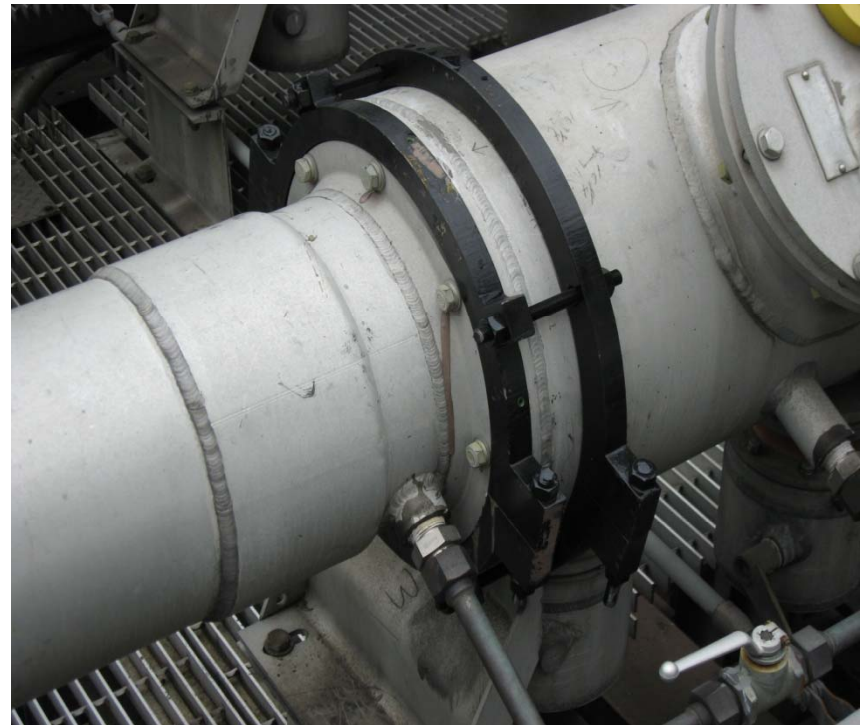


# SF6 Repairs

**Insulated Bus**



**Strong-back ring**



# Gas Breaker Leaks



# Leaking Casting Pores



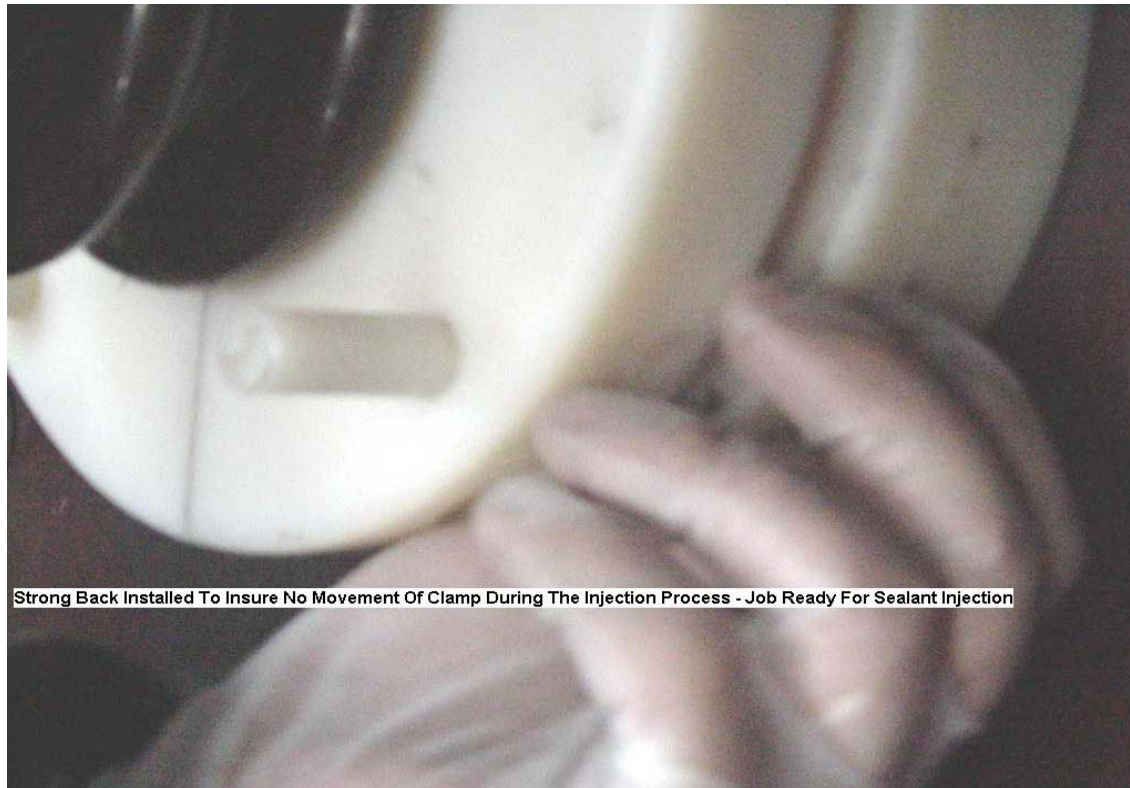
# Before-345 KV SF6 Breaker Leak



# SF6 Gas Bushing Flange Repair



# Bushing Leak Repair





# SF6 Tubing Leak



# Breaker Repair



# Colt Owned and Operated



Made from a solid block



# Colt Injectors



# S22 Sealant & Injection Gun



**REPORT**

**Issued to:** Mr. Jim Hackett  
Colt Atlantic Services, Inc.  
1845 South Lee Court, Unit C  
Buford, Georgia 30518

**Date of Report:** 3/ 8/03

**Report No:** 9051L

**Project:** Colt Atlantic Services

---

**Description:** Perform analysis of oil samples.

**SUMMARY**

Two (2) samples of electrical insulating oil were provided for analysis. One sample had been "contaminated" with the customer's two-part sealant (S-22).

The sealant was injected into the oil and allowed to cure. The oil was then analyzed.

Both samples were analyzed for dissolved gas content to determine if the presence of the sealant in transformer oil would generate additional combustible gases.

Results are provided for both sets of tests and there is no noticeable change in the total combustible gas content.

Carbon Dioxide, Nitrogen and Oxygen are non-combustible gasses that are present in air and therefore are not likely due to the presence of the sealant but instead due to exposure to air.

A second series of tests was performed on a solid piece of harden sealant. An AC hipot test was performed on the square sample at increasing voltages.

This report certifies that the above equipment has been tested in compliance with recognized standards or for safe use in a specific manner, or in accordance with Federal, State or Municipal regulations. The report is accurate and true to the best of our knowledge and belief. All equipment used in making physical determinations is accurate and bears recent and direct traceability to the National Bureau of Standards (NBS).

Burlington Electrical Testing Co., Inc.  
825 Sycamore Avenue  
Croydon, Pa. 19021 (215) 826-9400

By

---

Michael Johnson  
Project Manager

Colt Atlantic Services, Inc.

March 8, 2003  
Page 2

The sample was approximately 4" square and 1" thick. Tests were performed corner to corner and front to back at test voltages up to 35000 Volts AC.

The material performed a level of dielectric strength much greater than oil or air alone.

There is no indication from the tests performed that the presence of this sealant will negatively effect the oil.



Results of Dielectric Fluid  
Laboratory Tests  
Device History Report

Customer Name: **Colt Atlantic**  
 Project: **Colt Atlantic**  
 Device Designation: **Clean Control Sample**  
 Manufacturer: -  
 Serial Number: -  
 Fluid Type: **Mineral Oil**

Customer No: **C2548**  
 Report Date: **3/ 8/03**  
 Job No: **9051L**

<b>Dissolved Gas in Oil/R-Temp of the above device: (DGIO)</b>				
Date:	3/ 8/03			
Sample No:	Y3133			
Hydrogen (H2):	1			
Methane (CH4):	1			
Ethane (C2H3):	0			
Ethylene (C2H4):	0			
Acetylene (C2H2):	0			
Carbon Monoxide (CO):	0			
Carbon Dioxide (CO2):	647			
Nitrogen (N2):	35403			
Oxygen (O2):	17597			
Total Gas Content:	53649			
Total Combustible Gas:	2			

-----BURLINGTON ELECTRICAL TESTING COMPANY-----

Results of Dielectric Fluid  
Laboratory Tests  
Device History Report

Customer Name: **Colt Atlantic**  
Project: **Colt Atlantic**  
Device Designation: **Contaminated Sample**  
Manufacturer: -  
Serial Number: -  
Fluid Type: **Mineral Oil**

Customer No: **C2548**  
Report Date: **3/ 8/03**  
Job No: **9051L**

---

---

<b>Dissolved Gas in Oil/R-Temp of the above device: (DGIO)</b>			
Date:	<b>3/ 8/03</b>		
Sample No:	<b>Y3132</b>		
Hydrogen (H2):	<b>0</b>		
Methane (CH4):	<b>1</b>		
Ethane (C2H3):	<b>0</b>		
Ethylene (C2H4):	<b>0</b>		
Acetylene (C2H2):	<b>0</b>		
Carbon Monoxide (CO):	<b>1</b>		
Carbon Dioxide (CO2):	<b>707</b>		
Nitrogen (N2):	<b>41395</b>		
Oxygen (O2):	<b>22653</b>		
Total Gas Content:	<b>64757</b>		
Total Combustible Gas:	<b>2</b>		

Issued to: Colt Atlantic Services, Inc.  
P.O. Box 74396  
Richmond, VA 23236

Job No: 9051L

Project: Colt Atlantic Services, Inc.  
Richmond, VA

---

---

FIELD ENGINEER'S REPORT

---

---

A/C Hipot

Corner to Corner



Test Voltage Leakage

- 5,000:	.2	AC mA	
- 10,000:	.3	AC mA	
- 15,000:	.5	AC mA	
- 20,000:	.7	AC mA	
- 25,000:	.75	AC mA	Hear Tracking
- 30,000:	1.0	AC mA	Hear Tracking
- 35,000:	1.2	AC mA	Hear Tracking (5 Minutes)

Front to Back



- 5,000:	.2	AC mA
- 10,000:	.3	AC mA
- 15,000:	.5	AC mA
- 20,000:	.75	AC mA
- 25,000:	1.0	AC mA
- 30,000:	1.25	AC mA
- 35,000:	Flash over before.	

Leakage current is measured in AC milliamps.

# Summary

- Reduced or no outage time.
- Guaranteed for two-years.
- Can be re-injected if needed at a later date.
- Should not be used to replace re-gasketing.