

**AL-6XN<sup>®</sup> ALLOY:**  
**ALLOY OF THE 21<sup>ST</sup> CENTURY**  
**FOR AIR POLLUTION CONTROL**

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## ABSTRACT

Fossil fuel power plants are now faced with new air quality control laws and EPA regulations. New multi-pollutant legislation will control more emissions and more plants. How do you best economically achieve compliance with these regulations with available materials of construction for flue gas desulfurization (FGD) systems and wet electrostatic precipitators (WESP)?

A variety of austenitic alloys are available for use in FGD and WESP systems. Alloys with a molybdenum content varying 2 to 16 % have been used. The 6% Mo AL-6XN® superaustenitic alloy (UNS N08367) has performed better in laboratory testing and actual service conditions than the 3-5% Mo stainless steels 317L (UNS S31703), 317LMN (UNS S31726), and 904L (UNS N08904), and approaches the performance of 625 (UNS N06625) and C-276 (UNS N10276) in some environments. Lack of availability of 3-5% Mo stainless steels and the economic benefit over nickel based alloys have made N08367 alloy a fitting candidate for pollution control systems.

This paper concentrates in the use of N08367 alloy in many different FGD and WESP applications. Detailed service conditions at some of these plants will also be presented. N08367 alloy has been in service for over 10 years at several power plants with no reported problems. The data presented will also show the N08367 alloy is able to resist corrosion in high chloride low pH environments compared to other alloys and stainless steels.

Overall, N08367 alloy is shown to be a cost effective material of construction to fill the gap between the 4% Mo austenitic stainless steels and higher Mo nickel based alloys. As N08367 alloy is an established material of construction, it is readily available in product forms necessary to complete an FGD or WESP system.

## INTRODUCTION

Flue gas desulfurization (FGD) is one method for achieving the mandates of the Clean Air Act amendments. The use of lime or limestone slurries for “scrubbing” sulfur dioxide from flue gases has become an established technology. Modern scrubbers are capable of removing over 90% of the sulfur from the exhaust gas stream. For the FGD units to provide the desired improvement in air quality, they must operate reliably. Selection of suitable materials and proper fabrication are a vital part of the operability of the FGD process, and of power generation from fossil fuels.

A wide variety of metallic and non-metallic materials have been used for construction or repair of FGD equipment. Many different alloys have been employed. Due to increases in chloride contents, S31603 was found to be inadequate [1] resulting in a move to alloys with higher Mo contents. S31703 (3.2Mo) was specified followed by S31725 and N08904 (4.4Mo), then S31726 (4.4Mo), which also contains 0.15% nitrogen. Higher Nickel and Mo-bearing alloys such as N06625, N10276, and N06022 have also been utilized in more severe conditions.

Factors involved in choosing materials for FGD include the composition of fuel, the quality of the water used for scrubbing, the operating temperature, the build up of impurities (such as

chlorides) in the system, pH, possible upset conditions, scaling or deposit buildup, and galvanic interactions.

Modern FGD units are divided into several zones which have different corrosion problems and may be built from different alloys. The more severe zones, such as the inlet and outlet duct regions, are now typically constructed using nickel base alloys like N10276. The absorber, sump, and mist eliminator zones are usually much less corrosive and lower alloy materials are frequently employed there.

The purpose of this presentation is to review the properties and corrosion resistance of the 6% Mo alloy, AL-6XN® alloy (UNS N08367), in relation to FGD systems. In addition, typical current applications of the N08367 alloy in the FGD systems are described.

### **6% Mo SUPERAUSTENITIC ALLOY DEVELOPMENT**

In the early 1970s the AL-6X® (UNS N08366) alloy, containing 6.3Mo, along with 20Cr and 24Ni, was introduced [2]. Used primarily as welded power plant condenser tube in seawater, this material performed well [3,4]. High Cr and Mo provided excellent resistance to pitting and crevice corrosion [5-7] but also promoted intermetallic phases. Only thin gages could be produced.

Nitrogen suppresses intermetallic phases [8-9] and 0.2 percent was shown to be beneficial to the 20Cr – 24Ni – 6.3Mo alloy [10]. Nitrogen also improves pitting resistance and increases strength. These benefits, incorporated into the N08367 alloy in the early 1980s, permitted a full range of product forms and much broader applicability. The N08367 alloy has found many uses in power plants [11-12], oil refineries, chemical and petrochemical plants [13], and pulp mills, as well as in a variety of seawater applications [14].

### **CHEMICAL COMPOSITION**

The composition of N08367 alloy and other stainless steels and nickel alloys used in FGD systems are given in Table 1. The 6.2Mo and 0.22N in the N08367 alloy promote pitting resistance. Not all 6Mo alloys contain N and some have a higher or lower nickel content than N08367 alloy. Some of the other 6Mo alloys also contain Cu which may cause intergranular attack in high chloride environments. All of these alloys have a low carbon content and, thus, are “L” grades, highly resistant to sensitization and intergranular corrosion.

Compared to the more costly, high nickel alloys, the Mo content of the N08367 alloy is slightly lower than that of N06030 and significantly lower than that of N06625 and N10276.

### **PHYSICAL, MECHANICAL, AND FABRICATION CHARACTERISTICS**

Physical and mechanical properties of the 6Mo alloys have been widely discussed [11-14]. Mechanical properties, like those of the stainless steels and nickel alloys, are excellent. The N08367 alloy is readily welded to itself, other stainless steels, nickel based alloys, and carbon steel. Segregation occurs in as-cast matching-composition weld metal, leaving areas which are

low in Cr and Mo, making them susceptible to pitting [15, 16]. For this reason a weld filler metal with -higher Mo content is needed for proper as welded corrosion resistance. Nickel alloy 625 (AWS ERNiCrMo-3) filler metal and 112 (AWS ENiCrMo-3) electrodes provide welds with corrosion resistance and mechanical properties generally comparable to the N08367 alloy base metal [10]. Other high-Mo, nickel-base filler metals, such as N10276 alloy are also suitable.

## **CORROSION RESISTANCE**

Pitting and crevice corrosion are the primary reasons for failure in FGD environments. High Cr and Mo provide resistance, especially when present together [5-7]. Nitrogen is particularly effective in the superaustenitic alloys with high Mo content [10, 17, 18]. The Pitting Resistance Equivalent,  $PRE_N$ , based on Cr, Mo, and N content of the alloy is an indicator of pitting/crevice corrosion resistance. One popular  $PRE_N$  formula is:

$$PRE_N = Cr + 3.3Mo + 30N$$

The higher the  $PRE_N$ , the more resistant the alloy is to pitting and crevice corrosion in the presence of chlorides. Typical  $PRE_N$  values for the alloys mentioned so far are shown in Table 2. By listing the alloys by decreasing  $PRE_N$ , the 6% Mo alloys are positioned above (more resistant than) the conventional stainless steels and approaching the nickel alloys.

## **PAST LABORATORY WORK**

Extensive testing has been performed comparing N08367 alloys to stainless steels and higher Ni-Mo alloys. Testing ranges from standard ASTM corrosion testing to simulated FGD environments. Data from these tests are shown in the following tables.

The ferric chloride crevice corrosion data shown in Table 2 is generated from ASTM G48-B. The capability of the N08367 alloy with 6.2Mo is seen to be close to that of nickel-base N06625 alloy (9Mo) and significantly better than N08904 and S31726 alloys containing about 4.4Mo. In the ferric chloride test without crevices, ASTM G48-A, the N08367 alloy withstands pitting at 62°C (145°F). Good correlation between ferric chloride temperature capability and  $PRE_N$  was observed in this summarized data.

The effect of 1,000 ppm thiosulfate on corrosion in 10,000 ppm chloride environment is shown in Table 3. Corrosion is aggravated on the S31603 alloy at all pH levels by the thiosulfate addition. When pH was adjusted to 1.0 with  $H_2SO_4$ , all alloys including N08367 and N10276 materials were significantly affected. The addition of thiosulfate to control in limestone FGD systems, thus, has potential for initiating or aggravating corrosion on stainless steels, and even N10276 alloy, under conditions of low pH or otherwise borderline passivity. These findings are in agreement with previous studies [19].

Table 1  
 Typical Composition (wt.%) of Other Stainless Steels  
 And Nickel –Base Alloys Used in FGD Systems

UNS Number	Alloy	Cr	Mo	Ni	Fe	Other
S31803	2205	22.1	3.0	5.6	Balance	0.12N
S32205	2205	22.1	3.1	5.6	Balance	0.16N
S32550	255	25.5	3.1	5.7	Balance	0.17N
S31603	316L	16.4	2.1	10.1	Balance	
S31703	317L	18.4	3.2	12.7	Balance	
S31725	317LM	18.8	4.4	14.3	Balance	
S31726	317LMN	19.2	4.4	16.5	Balance	0.15N
N08904	904L	20.4	4.4	24.5	Balance	1.4Cu
N08367	AL-6XN	20.5	6.2	25.0	Balance	0.22N
N08825	825	20.6	2.7	41.0	Balance	1.5Cu, 1.1Ti
N06007	G	22.0	6.5	Balance	20	1Co, 2Cu, 2(Cb+Ta)
N06625	625	21.0	9.0	Balance	4.6	3.4(Cb+Ta)
N10276	C-276	15.5	15.4	Balance	6.4	3.4W, 1.2Co, 0.15V

Table 2  
 Temperature for Initiation of Crevice Corrosion  
 in 10% Ferric Chloride (FeCl<sub>3</sub>·6H<sub>2</sub>O) Solution (1)  
 $PRE_N = Cr + 3.3Mo + 30N$

UNS Number	% Mo	°F (°C)	PRE <sub>N</sub>
S31603	2.1	27 (-3)	23
S31703	3.2	35 (2)	29
S31726	4.4	68 (20)	34
S31803	3.0	68 (20)	35
S32205	3.1	68 (20)	38
N08904	4.4	75 (24)	35
S32550	3.1	72 (22)	41
N06007	6.5	86 (30)	43
N08367	6.2	110 (43)	48
N06625	9.0	113 (45)	51
N10276	15.4	130 (55)	66

(1) per ASTM G 48 Practice B

Table 3  
 Crevice Corrosion of Stainless Steel and Nickel Alloy(1) [22]  
 10,000 ppm Chloride and 1,000 ppm Thiosulfate 72 Hours at 66°C (150°F)

Alloy	Weight Loss, g/cm <sub>2</sub> [No. Crevice Sites Attacked] (2)			
	pH 1 (3)	pH 2	pH 4.5	pH 6.5
A.	10,000 ppm Chloride (as NaCl)			
S31603	0.0000[29]	0.0000[13]	0.0000[11]	0.0000[10]
S31725	0.0000**	0.0000[10]	0.0000[2]	0.0000[4]
S31726	0.0000**	0.0000[1]	0.0000[1]	0.0000[1]
N08367	0.0000[19]	0.0000[0]	0.0000[0]	0.0000[0]
N10276	0.0000[0]	0.0000[0]	0.0000[0]	0.0000[0]
B.	10,000 PPM Chloride (as NaCl), 1,000 ppm Thiosulfate (as Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub> )			
S31603	0.0142[40]	0.0002[40]	0.0000[27]	0.0003[17]
S31725	0.0070**	0.0000[3]	0.0000[1]	0.0000[0]
S31726	0.0009[39]	0.0000[1]	0.0000[0]	0.0000[0]
N08367	0.0013[40]	0.0000[0]	0.0000[0]	0.0000[0]
N10276	0.0011[40]	0.0000[0]	0.0000[0]	0.0000[0]

- (1) Crevice generated using Delrin™ serrated spacers tightened to 55-60 in-lbs.
  - (2) Weight loss is average of duplicate specimens. Numbers in brackets are the maximum number of crevice contact sites (out of 40 total) evidencing corrosion.
  - (3) Sulfuric acid used to adjust pH
- \*\* General corrosion observed

Test data from a 30 day exposure to water containing 12,100 ppm chloride at 71°C (160F) with pH adjusted to 2, are shown in Table 4. The N08367 alloy with 6.2Mo, and alloys with higher Mo alloys, The N08367 alloy with 6.2 Mo, and alloys with higher Mo content (N06007 and N06625), did not corrode. Lower Mo alloys, S31603 and N08904, exhibited attack with less corrosion observed on the N08904 material.

Test data from another source [20] comparing critical pitting and critical crevice corrosion temperatures are shown in Table 5. This solution contained 24,300 ppm chlorides and is acidic (pH 2). This data showed N08367 alloy having a slightly higher critical crevice temperature than N06030 alloy. It also out performed S31254 and S32250.

Test data from 24,000 ppm chloride water with temperature varied from 43°C (110°F) to 71°C (160°F) and varied from 4 to 0.5 with H<sub>2</sub>SO<sub>4</sub> are presented in Table 6 for the N08367 alloy. No corrosion was observed at pH 4 or 2. With pH adjusted to 1.0, corrosion was not observed up to and including 66°C (150°F). However, at 71°C (160°F) crevice corrosion was observed. With pH 0.5, no corrosion was observed at 60°C (140°F) but crevice attack was observed at 66°C (150°F).

Table 4  
 Laboratory Crevice Corrosion Test of Alloy (1)  
 12,100 ppm Chlorides (as NaCl), pH 2,  
 30 Day Exposure, 71°C (160°F)

Alloy	Mo Content	Weight Loss g/cm <sup>2</sup>	Comments
S31603	2.2	0.0000	Micropits and Crevice Attack 0.058cm (0.023 in)Depth
N08904	4.5	0.0000	Crevice Attack to 0.010cm (0.004 in) Depth
N08367	6.2	0.0000	No Corrosion
N06007	6.5	0.0000	No Corrosion
N06625	9	0.0000	No Corrosion

(1) Testing per ASTM G48-B Procedures, Average of Duplicate Tests

Table 5  
 Comparative Immersion Critical Pitting &  
 Critical Crevice-Corrosion Temperatures in Oxidizing NaCl-HCl Solution (1)

UNS Number	Critical Pitting Temperature	Critical Crevice-Corrosion Temperature
	°C (°F)	°C (°F)
N06022	>150 (>302)	102 (216) Boiling
N10276	150 (302)	80 (176)
N06625	90 (194)	50 (122)
N08367	70 (158)	45 (113)
N06030	70 (158)	40 (104)
S31254	60 (140)	40 (104)
S32550	50 (122)	35 (95)
N08904	45 (113)	20 (68)
S31725	35 (95)	15 (59)
S31603	20 (68)	<-5 (<23)

(1) Solution = 4% NaCl + 0.1% Fe<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> + 0.1% M HCl  
 Solution contains 24,300 ppm chlorides and is acidic (pH 2)

Table 6  
24,000 PPM Chloride Water  
With pH and Temperature Varied (1)

Temperature °C (°F)	Weight Loss, g/cm <sup>2</sup> (2)			
	pH 0.5 (3)	pH 1	pH 2	pH 4
43 (110)	0.0000	0.0000	0.0000	0.0000
49 (120)	0.0000	0.0000	0.0000	0.0000
54 (130)	0.0000	0.0000	0.0000	0.0000
60 (140)	0.0000	0.0000	0.0000	0.0000
66 (150)	0.0186	0.0000	0.0000	0.0000
71 (160)	-	0.0234	0.0000	0.0000

- (1) 30 day tests, procedures per ASTM G48-B
- (2) Average of two tests
- (3) pH adjusted with H<sub>2</sub>SO<sub>4</sub>

Crevice corrosion data from a Severe Laboratory Acid Chloride Solution (Green Death) are given in Table 7. Crevice corrosion is observed on S31603 and S31703 at room temperature. At 50°C (122°F) alloys with up to 4.4Mo are corroded. The N08367 (6.2Mo) alloy and higher Mo nickel-base materials resist attack. Further increase in temperature to 70°C (158°F) resulted in significant crevice corrosion on all alloys through the 9Mo N06625 alloy. The 16Mo N10276 alloy exhibited only superficial crevice corrosion.

Table 7  
Crevice Corrosion Testing in Simulated  
Scrubber Environment (Green Death)

Alloy	Weight Loss g/cm <sup>2</sup> (2)		
	25°C (75°F)	50°C (122°F)	70°C (158°F)
S31603	0.0006	0.0343	0.0390
S31703	0.0007	0.0377	0.5000
S31725	0.0000	0.0319	0.0462
S31726	0.0000	0.0129	0.0462
N08904	0.0000	0.0221	0.0419
N08367	0.0000	0.0000	0.0266
N06625	0.0000	0.0000	0.0149
N10276	0.0000	0.0001	0.0004

- (1) 7 Vol. % H<sub>2</sub>SO<sub>4</sub>, 3 Vol. % HCl, 1 Wt. % CuCl<sub>2</sub>, 1 Wt. % FeCl<sub>3</sub>
- (2) Tests per ASTM G48-B procedures, 72 hour duration

Coupons of N08367 alloy were exposed to an SO<sub>2</sub> absorber environment. The coupons were exposed in the presence of SO<sub>2</sub> to calcium chloride brines having chloride concentrations of 10,000, 20,000, 30,000, 50,000, and 100,000 ppm at temperatures of 55°C and 80°C. The results of visual evaluations and the apparent corrosion rates of all the test alloys are summarized in Tables 8 and 9. Most of the N08367 alloy coupons exhibited some staining but no significant etching or corrosion attack. The apparent corrosion rate of was 0.1 mpy or less in coupons exposed at 55°C. At 80°C, a maximum apparent corrosion rate of 0.3 mpy was measured in the coupon that was exposed to 30,000 ppm chloride brine. Measured rates were 0.1 mpy or less in all of the other N08367 coupons. In some instances, the N08367 samples were better and in other cases worse than the “generic” 6Mo alloy samples. Overall, the performance of the N08367 material was equivalent to that of the “generic” 6Mo alloy.

Similar testing was performed under actual service conditions. This data was presented in 2000 [21] and some is recapped in this presentation. The laboratory results support the conclusion that N08367 alloy should exhibit corrosion resistance equal to that described for the “generic” 6Mo alloy in that study, which was performed in real, operating FGD units.

One plant where these tests were performed was Orlando Utilities – Stanton Energy Plant. Various alloys were tested for 270 days. The slurry average chloride content was ~70,000 ppm, the pH was 5.6, and the temperature was ~130°F (54°C). Data can be seen in Table. Figure 1 shows the alloy samples after testing. Note the 6-moly and N10276 displayed very good corrosion resistance. Crevice corrosion on a S31603 specimen with loose crevices was almost as severe as one with tight crevices. Localized attack incurred by the S31726 stainless steel was considerably less than that suffered by S31603 stainless steel, but nevertheless still quite severe. One of the duplex stainless steel specimens exhibited under-scale type etching. The conditions at this plant were the most severe out of any of the testing. The 6-moly performed equal to the N10276 alloy in the other tests.

**Figure 1**  
**This shows decreasing levels of corrosion (from left to right) after 270 days inside of Orlando Utilities’ Stanton Energy Center in Florida**

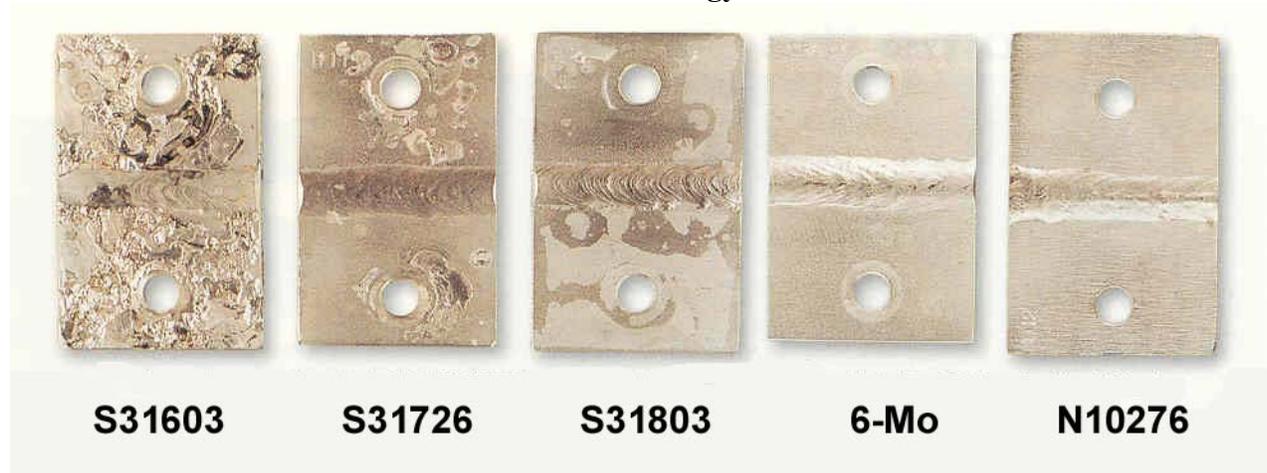


Table 8  
Results of Visual evaluation of the unwelded coupons after descaling.

Alloy	Attack Index – Front/Back				
	1% °C	2% Cl <sup>-</sup>	3% Cl <sup>-</sup>	5% Cl <sup>-</sup>	10% Cl <sup>-</sup>
Temperature = 55°C					
S31603	3/3	3/3	3/3	3/3	3/3
S31726	1/2	0/2	1/1	0/1	3/3
S31803	0/0	0/1	0/1	0/1	0/1
“generic” 6% Mo Alloy	0/0	0/1	0/1	0/1	0/1
N08367	0/1	0/1	0/1	0/1	1/2
N10276	1/1	1/1	1/1	1/1	1/1
Temperature = 80°C					
S31603	3/3	3/3	3/3	3/3	3/3
S31726	3/3	2/3	2/3	1/2	1/2
S31803	2/2	2/2	2/2	1/1	1/2
“generic” 6% Mo Alloy	0/0	0/1	0/1	0/1	0/2
N08367	0/1	0/1	1/2	0/1	0/2
N10276	1/1	1/1	1/1	1/1	1/1

Attack Index: no attack = 0, tarnish or light attack = 1  
Moderate attack = 2, and severe attack = 3

Table 9  
Apparent corrosion rate of unwelded alloys  
in simulated SO<sub>2</sub> absorber environments.

Alloy	Apparent Corrosion Rate, mpy				
	1% °C	2% Cl <sup>-</sup>	3% Cl <sup>-</sup>	5% Cl <sup>-</sup>	10% Cl <sup>-</sup>
Temperature = 55°C					
S31603	4.1	3.9	5.4	7.3	5.3
S31726	0.2	0.1	0.1	0.1	1.3
S31803	0.2	0.2	0.1	0.0	0.1
“generic” 6% Mo Alloy	0.0	0.0	0.0	0.0	0.0
N08367	0.0	0.0	0.0	0.0	0.1
N10276	0.1	0.2	0.1	0.1	0.1
Temperature = 80°C					
S31603	5.8	4.2	2.7	3.2	3.8
S31726	1.7	1.0	0.5	0.4	0.2
S31803	2.1	1.3	1.1	1.3	0.4
“generic” 6% Mo Alloy	0.0	0.1	0.0	0.0	1.1
N08367	0.1	0.0	0.3	0.0	0.0
N10276	0.4	0.6	0.4	0.5	0.3

## N08367 ALLOY FGD SYSTEM & POWER PLANT APPLICATIONS

**Northern Indiana Public Service Company (NIPSCO) –Bailly Generating Station Units #7 & 8.** This station uses 2 to 4.5% sulfur bituminous coal. Pure Air on the Lake manages this FGD system. N08367 alloy has been used in several applications in this system. The successful performance of N08367 alloy in earlier applications has led to its utilization in other areas of the FGD system. Estimated conditions of the absorber are ~11,000 ppm chlorides, pH of 6, and 125°F

- Original construction consisting of N08367 alloy recirculation piping, spray piping system, and rotary sparger unit (submerged in the limestone scrubber tank) have been in service for over 12 years. See Figures 2 & 3.
- In 1997, N08367 alloy was fabricated into top hats to protect flanged connections in rubber lined steel pipe for slurry pipe headers and the spray piping systems. Top hats were also installed in other areas in more recent times. See Figure 4.
- In 1997, N08367 alloy strips were installed over N10276 welds that were eroding. This problem occurred in the wet-dry zone. No reported problems. See Figure 5.
- In 2003, N08367 alloy box beams replaced rubber coated carbon steel beams. These beams, located in the absorber tower, support a 28,000 piece grid packing system. See Figure 6.



**Figure 2: N08367 Alloy Rotary Sparger**



**Figure 3: N08367 Alloy Spray Piping**



**Figure 4: N08367 Alloy Top Hats**



**Figure 5: N08367 Alloy Strips Covering Welds**



**Figure 6: N08367 Alloy Box Beams**

**REPLACED**



**Rubber Coated Carbon Steel Beams**

### **Louisville Gas & Electric (LG&E) – Cane Run Station Units #5 & 6**

This station burns 3.5% sulfur coal. N08367 has been used in several applications in this system estimated chloride levels in the Unit #6 absorbers are ~5500 ppm. Unit #5 absorber is ~800ppm.

- In 1990, N08367 alloy replaced S31726 lining in two FGD downcomer ducts. See Figure 7. The S31726 liner failed in less than 3 years due to perforation from pitting. 14ga and 16ga sheet was used to wallpaper the duct. The N08367 alloy is still in service after 12 years.
- In 1999, N08367 alloy replaced a 16" coated carbon steel pipe for the pump suction system used to recirculate the scrubber liquor that quenches the flue gas in the absorber tower.
- The carbon steel supporting beams that support the absorber trays were wallpapered with N08367 alloy.
- In 2003, N08367 alloy was fabricated into liquid distribution rings in the absorber tower. These were installed to protect the absorber tower walls.

**Figure 7: LG&E Cane Run #6 Absorber Tower and Downcomer**



### **Korea Electric Power Company (KEPCO) – Taean Units 1-4, Hadong Units 1-6.**

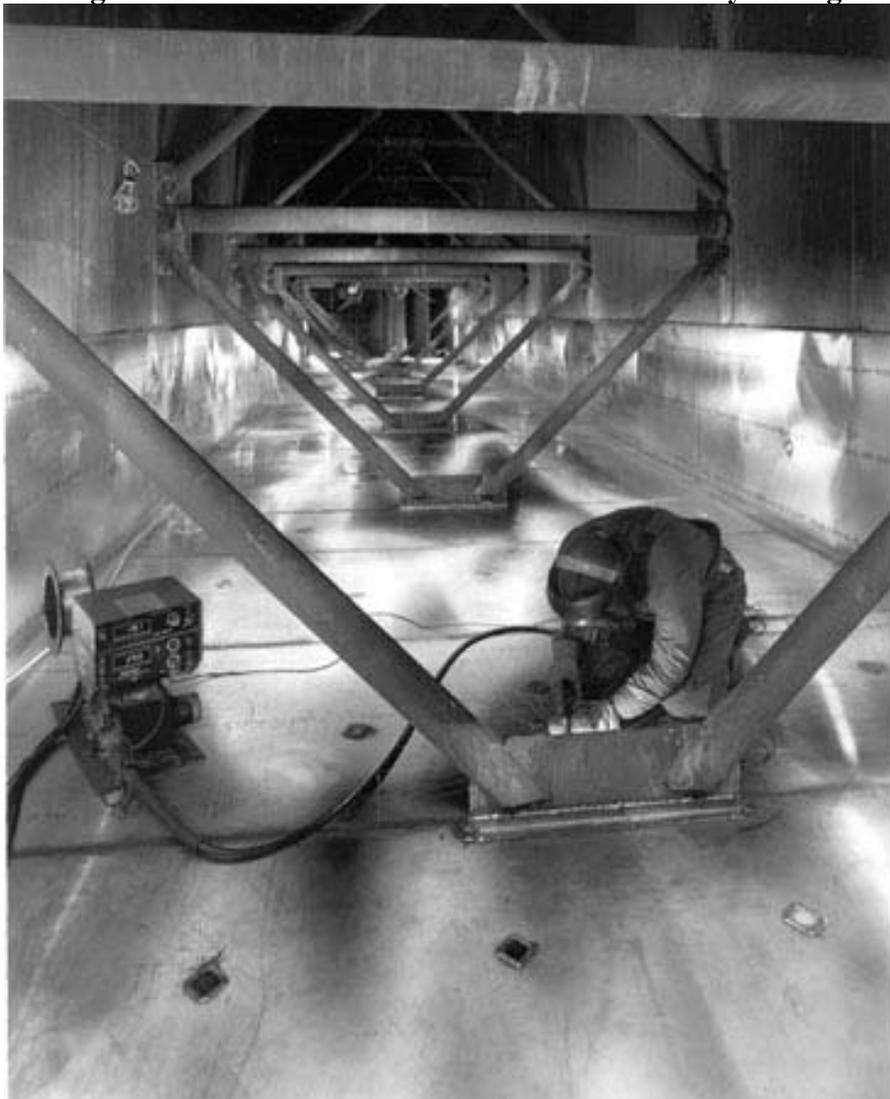
These two stations started eight units in 1998 and an additional two in 1999. No reported problems since installation. Each of the 10 wet limestone absorber towers was 55 foot in diameter and serviced a 500MW boiler. N08367 alloy was used for absorber tower plates, internals including stiffeners and structurals, piping systems, and the absorber trays. Inlet SO<sub>2</sub> concentration was 645 ppm and chloride levels were ~20,000 ppm maximum. The N08367 alloy for this major FGD project was produced to demanding requirements for corrosion resistance, surface cleanliness, and tight dimensional tolerances.

### **Indianapolis Power & Light (IP&L) – Petersburg Station**

N08367 alloy was used for the wallpapering of a carbon steel duct connecting the electrostatic precipitator to the flue stack. Lower than expected temperatures led to condensation in the bottom of the 12 foot wide duct. The duct was approximately 150 feet long. 35,000 pounds of 14ga N08367 alloy sheet were supplied to wallpaper the bottom of the duct to protect against corrosion by the condensate which would include sulfurous acid and chlorides. Gas estimates through the duct were 33 lbs/hour of  $Cl^-$  and 29 lbs/hr of  $SO_2$ . The lining and duct are shown in Figure 8.

After 5 years in service the duct was removed from service with no reported problems. Reason for removal was the installation of the of a wet FGD system. Due to the success of N08367 in this application, it was selected for portions of the absorber tower contacted after the quench section.

**Figure 8: IP&L Flue Gas Duct with N08367 Alloy Lining**



### **Central Illinois Public Service Company (CIPS) – Newton Power Station**

N08367 alloy was fabricated into a turning vane for a flue gas stack. The turning vane was installed to address an undesirable cyclone effect at the base of the flue gas stack. Excellent resistance to pitting and crevice attack was demonstrated by the N08367 alloy, necessary for this plant which burns high sulfur coal. The N08367 alloy was chosen based on corrosion testing. The scrubber was decommissioned in 1994, but CIPS reported that the N08367 performed well in resisting corrosion over several years of service. The vane can be seen in Figure 9.

**Figure 9: CP&L Turning Vane**



### **American Electric Power (AEP) – Conesville Plant**

N08367 alloy plate was chosen as a replacement alloy for the bypass interface wet/dry interface in an existing FGD system. Installed in early 2003.

### **American Electric Power – Pirkey Station**

N08367 alloy sheet is currently in test on the sidewalls of the outlet duct of the FGD system. AEP is wallpapering over 1/4" S31703 stainless sheet which has perforated.

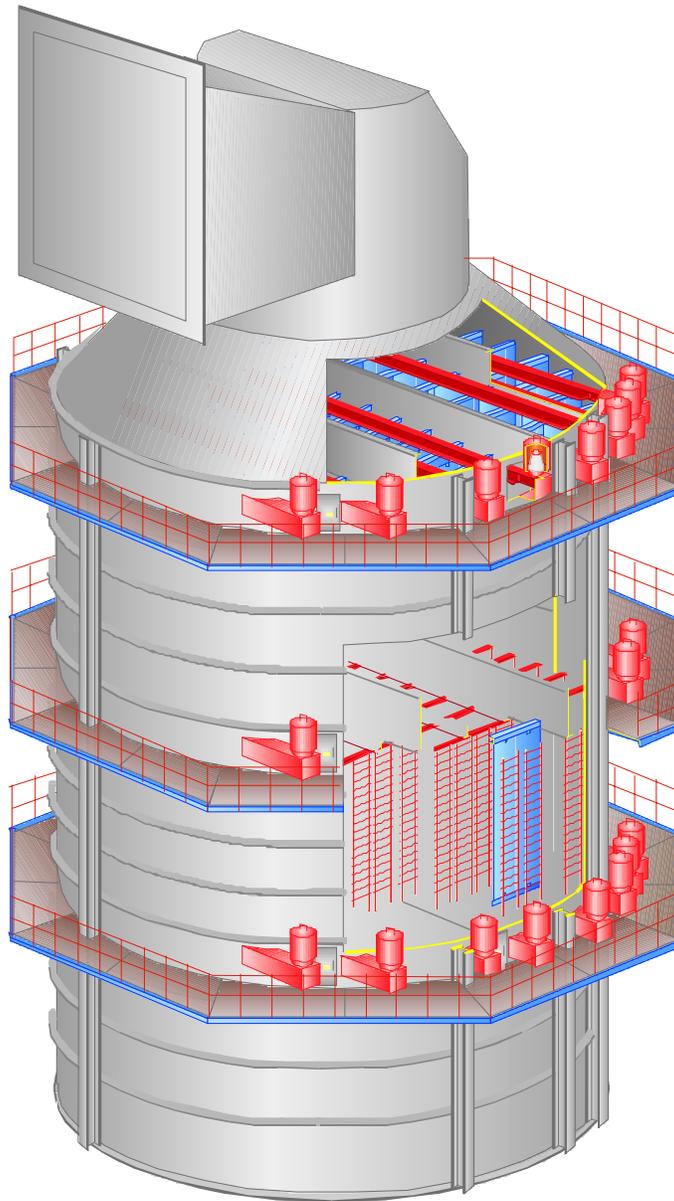
### **Intermountain Power – Delta Plant**

N08367 alloy pipe and plate were chosen for a forced oxidation piping system in an existing FGD system. Installed in early 2003.

### **New Brunswick Power – Colson Cove Power Plant**

Over 14,000 feet of N08367 box beams were furnished for use in a wet electrostatic precipitator (WESP). These beams were drawn to an overall size of 1.0" x 6.0" x 0.120" average wall for the application. Over 300,000 lbs of N08367 alloy sheet was also supplied for use as collector plates, which were hung from the box beams. The box beams and collector plates can be seen in the cut outs of Figure 11.

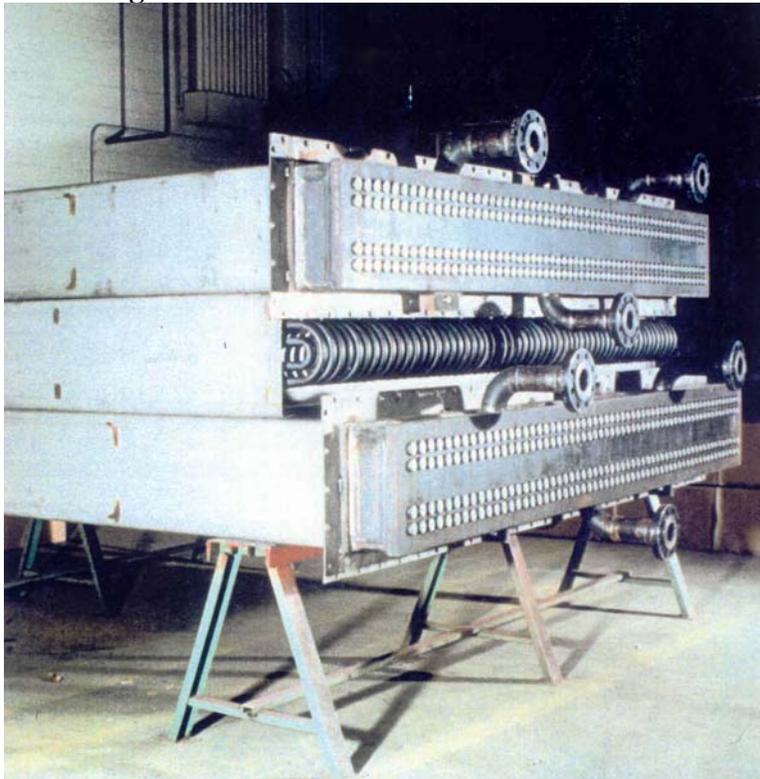
**Figure 11: WESP at Colson Cove**



### **Electric Power Heat Exchangers & Condensers**

Tubes and tubesheets of N08367 alloy are in use in direct flue gas reheaters [##]. The N08367 U-tubes carry steam to reheat cold, wet scrubber flue gas before it reaches the exhaust stack. Three stacked heater bundles are shown in Figure 11. The frame and baffles for these modules are fabricated of the S31725 alloy. The N08367 tubes and tubesheet replaced N08825 alloy components which had previously been used and failed. Corrosion test data, which illustrated the N08367 alloy provides a substantial improvement in resistance to acid chloride environments, were used as an aid in selection. The N08367 alloy was a cost-effective alternative to the high-Mo nickel-based alloys.

**Figure 11: Three Stacked Heater Bundles**



### **SUMMARY**

N08367 alloy has been in many applications in FGD systems. These include absorber bodies, ducting, mixers, spargers, spray piping, turning vanes, dampers, lining, reheaters, spray absorbers, and structural supports. This alloy has also been installed for many years, by the millions of feet, in the power industry in seawater cooled steam condensers. Many coastal power plants have also utilized N08367 for service water piping.

Overall, the 6.2Mo N08367 alloy is shown to be a cost effective material of construction to fill the gap between the 4.4Mo austenitic stainless steels and higher Mo nickel-based alloys. This material is available in a wide variety of product forms (plate, sheet, strip, bar, tube, pipe, fittings, flanges, etc.) needed to meet the requirements of all FGD and WESP system components.

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