Refrigerant Loading Effects on Carbon during Bypass Leakage Testing

William P. McDonald
Commonwealth Edison Company
Zion, Illinois

John R. Pearson
NCS Corporation
Columbus, Ohio

Dennis G. Adams
Commonwealth Edison Company
Downers Grove, Illinois

Abstract

Regulatory Guides 1.52 and 1.140, require that 'air flow through the unit should be maintained until the residual refrigerant gas in the effluent is less than 0.01 ppm'. [1,2] Several industry forums have focused on how to meet this requirements. [3] No technical basis could be found to justify the .01 ppm refrigerant effluent requirement other than the untested concern that the refrigerant might block adsorption sites on the nuclear grade carbon reserved for iodine removal during a design basis accident. What are the true effects on the carbon if the R-11 level is greater than 0.01 ppm? What is the safety significance of such a requirement? Should the utility industry wait until the issue is elevated by higher authority or should we as an industry, confront the deficiency and correct it for everyone? This paper will show that this is not a technical or operability concern and serves as an unnecessary burden on the utility and that relief should be promulgated by the staff on behalf of the utilities. Revision of the applicable regulatory guides has been long coming; however, the utilities can ill-afford to continue without sufficient uniform technical guidance.

Compliance Issues

Verbatim compliance to Technical Specifications and the station FSAR and also to commitments to Regulatory Guides and referenced ANSI standards is a requirement for any station. Investigation of the .01 ppm requirement has revealed that insufficient industry and regulatory guidance exists. The system manager and design engineer is left with station procedures to ensure compliance to this issue. It is easy to ask the question, "How do you know you are in compliance with the 0.01 ppm requirement in the regulatory guide?" The burden has been left up to the utility to provide the technical justification to meet this requirement long after the regulatory guide has been issued. One station issued an LER on this specific requirement for 'lack of verbatim compliance' yet direction on specifically how to meet this requirement was not available. Stations have issued technical specification interpretations, made changes to the technical specification design bases or have issued engineering evaluations all in an effort to avoid the appearance of 'lack of verbatim compliance' which has proven to be costly to the utility.

Industry Actions

A general industry inquiry was initiated to determine how other stations that performed the testing in-house were able to meet this requirement. Of those that were aware that it indeed was a requirement to be met in the Regulatory Guide 1.52, the methodology that that was used to meet this requirement varied. The level of commitment varied from no action to running until the level is less than .01ppm regardless of the additional run time it adds to the carbon bed. This procedure often took days to complete. New carbon is known to adsorb the R-11 quite effectively and release its R-11 very slowly, while used/moisture laden carbon tends to adsorb R-11 poorly and release its adsorbed refrigerant quite rapidly. This effect is due to adsorbed organic material and water blocking the carbon's adsorption sites.

Some stations simply performed the required 10-hour run time surveillance at the conclusion of the in-place bypass leakage test on the carbon bed for the ESF units and assumed the R-11 was desorbed sufficiently. Others performed the same action and measured the R-11 concentration and compared it to the background level of R-11 on the bed measured earlier. Some stations assured the charcoal filtration unit continued to run until the R-11 was less than 0.01 ppm. In one case, the unit ran for three days with no change in the level of R-11. What if the background level on the charcoal bed is greater than .01 ppm prior to injection? What is the utility action then? Does the utility know how to tell when the R-11 level is less than .01 ppm? The industry response to this question varied as well, regardless of the test equipment being used.

Plant In-Place Testing

Table 1 describes four carbon samples that were taken from a commercial nuclear plant. The samples vary from relatively new carbon that is installed in a small bed to extended life carbon that is installed in a large bed.

Table 1 Carbon Data

Sample No.	Charcoal Type	No. Trays/Filter Bank	In-place Days/Yrs	Inservice Hours
1	3.5% TEDA	6	2146/6yrs	720
2	3.5% TEDA	8	146/.4 yrs	3504
3	3.5% TEDA	91	2372/6.5 yrs	>8582
4	3.5% TEDA	91	1797/5 yrs	>13890

Table 2 describes R-11 loading after a in-place leak testing with the following assumptions:

1. 150 lbs. of carbon filtering 1000 cfm of air. (40 fpm through a 2" bed)
2. Test duration is 10 minutes.
3. No desorption occurs during testing.

Table 2 R-11 Concentration

PPM	% R-11 by Weight on Carbon
0.01	0.0000233
5	0.0117
10	0.0233
20	0.0466
429	1.0
858	2.0

Test Procedure

The radioiodine test procedure ASTM D3803-1979 was used for evaluation because carbon classified as "used" is not pre-equilibrated with humid airflow prior to loading with methyl iodide. [4] The pre-equilibration air flowing through the test carbon has the possibility of sweeping the R-11 from the carbon before the methyl iodide is injected. Testing was also conducted using ASTM D3803-1989 because it is considered the most challenging protocol. ASTM D3803-1989 is the radioiodine testing protocol that is being adopted by both industry and regulatory agencies. [5]

Each sample of nuclear carbon was separated into two parts. The first sample was set aside for use as the control (no R-11 added). The second sample was placed in a glass bottle sitting on an analytical balance. Refrigerant-11 was added using a small syringe in several additions until the carbon contained 1.0% or 2.0% by weight. The carbon was immediately capped and then mixed. The bottle containing the carbon was allowed to stand for a minimum of 24 hours with occasional mixing before radioiodine testing.

Radioiodine Testing

All radioiodine penetration testing was conducted at NCS Corporation's carbon testing laboratory located in Columbus, Ohio. Each NCS test system is capable of testing up to four (4) carbon samples simultaneously when all test conditions, excluding face velocity, are identical. The system is ideal for measuring small differences in radioiodine penetration between two or more charcoal samples.

The test system configuration allows multiple carbon samples to have their iodine penetrations measured using common test parameters. The following test parameters are common to each charcoal sample when it is tested at the same time in the same test system:

Temperature
Pressure
Relative Humidity
Adsorbate Concentration
Duration of Loading
Duration of Post Sweet
Equilibration Time
Pre-Equilibration
Chemical Form of Iodine (CH_3I or I_2)

The only test parameter that is not common to each test carbon isface velocity. The NCS test system uses vortex shedder velocity indicators to measure the actual face velocity of the humid air passing through each test carbon bed. Vortex shedder meters are extremely accurate and stable allowing precise measurement of the flow. Additionally, each vortex shedder is backed up by a mass flow controller.

The carbon used for these tests was used carbon that had been in service for 2 years (Filter Unit A) and carbon that was nearing the end of effective service life (Filter Unit B). Both systems have a maximum radioiodine penetration limit of 5%. The carbon came from systems installed in an operating PWR nuclear station's Fuel/Auxiliary Building. Table 3 shows eight samples, four of which use ASTM D3803-79 "used" protocol with no equilibration and four samples using the ASTM D3803-89 protocol with its 18 hours of pre/equilibration. The % R-11 loading was either 0% or 1% with results as shown:

Table 3 Test Results

Filter Unit	Protocol	Parameters C°/ %RH	% R-11 Loaded	Resulting Efficiency
A	ASTM D3803-79	51.7/95	1	95.16%
A	ASTM D3803-79	51.7/95	0	95.36%
A	ASTM D3803-89	30/95	0	72.35%
A	ASTM D3803-89	30/95	1	71.89%
B	ASTM D3803-79	51.7/95	1	99.98%
B	ASTM D3803-79	51.7/95	0	99.98%
B	ASTM D3803-89	30/95	0	98.59%
B	ASTM D3803-89	30/95	1	98.63%

Table 4 shows laboratory test results for four different filtration units. For each test, ASTM D3803-1979, Method A was used as a test method. Each sample was tested with and without R-11.

Table 4 Carbon Lab Test Results

Filter Unit	Sample No.	Standard Test % Penetration (No R-11)	Standard Test % Efficiency (No R-11)	Test with 2% R-11 % Penetration	Test with 2% R-11 % Efficiency	Test Differences % Penetration	Test Differences % Efficiency
A	1-Upstream	0.01%	99.99%	0.01%	99.99%	0	0
A	1-Dwnstrm	0.01%	99.99%	0.01%	99.99%	0	0
B	2	0.01%	99.99%	0.01%	99.99%	0	0
C	3	4.52%	95.48%	4.66%	95.34%	+0.14	-0.14
D	4	0.20%	99.80%	0.20%	99.80%	0	0

Conclusion

Based upon the testing, R-11 concentrations at typical test conditions do not affect the carbon's radioiodine removal performance. In fact, the presence of gross amounts of R-11 in excess of inlet concentrations of 20 ppm on the carbon has no measurable detrimental effects on the radioiodine performance on nuclear grade activated carbon. The Regulatory Guide 1.52 or 1.140 requirement to run systems until the R-11 concentration is less than .01 ppm is overly conservative and can result in unnecessary run time applied to carbon beds. Based on the results of the above testing, it is clear that the presence of gross amounts of Refrigerant-11 on nuclear grade activated carbon has no measurable effect on the radioiodine penetration.

Industry Recommendations

Based on this study, we recommend the following actions:

- Delete reference to the 0.01 ppm effluent concentration in future Reg. Guides 1.52 and 1.140 revisions
- Issue clarification/guidance to USNRC residents that this is not a technical concern or operability issue.
- Provide relief to stations-USNRC
- Seek regulatory action to dispose of this issue without a formal technical specification change.

References

1. Regulatory Guide 1.52, DESIGN, TESTING AND MAINTENANCE CRITERIA FOR ATMOSPEHERE CLEANUP SYSTEM AIR FILTRATION AND ADSORPTION UNITS OF LIGHT-WATER-COOLED NUCLEAR POWER PLANTS.
2. Regulatory Guide 1.140, DESIGN, TESTING AND MAINTENANCE CRITERIA FOR NORMAL VENTILATION EXHAUST SYSTEM AIR FILTRATION AND ADSORPTION UNITS OF LIGHT-WATER-COOLED NUCLEAR POWER PLANTS.
3. NHUG-Nuclear HVAC Utility Group Conferences (1996-1998).
4. ASTM D3803-79, Standard Test Method for RADIOIODINE TESTING OF NUCLEAR-GRADE GAS-PHASE ADSORBENTS.
5. ASTM D3803-89, Standard Test Method For Nuclear-Grade Activated Carbon.