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R-3/D2 #31

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August 9, 1991

George H. Bidinger, Section Leader
Uranium Fuel Section
Fuel Cycle Safety Branch
Division Of Industrial and
Medical Nuclear Safety, NMSS
U. S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: SPENT LIMESTONE SAMPLING

Dear Mr. Bidinger:

Enclosed is a report describing a new sampling procedure for spent limestone as it is unloaded from the dry scrubbers. The report also includes a study to compare contamination levels from different elevations in the scrubbers. It concludes that there is no statistically significant difference in results between the different elevations, and that all results are within the 30 pCi/gram release limit. However, sampling at the bottom of the scrubber would efficiently detect a contamination event, should it occur.

We believe that this improved sampling and analysis procedure adequately supports our request for approval to release spent limestone as on-site unrestricted area fill material, and would like to discuss the results of this study with you during your visit to Hematite on August 19-20.

Cordially yours,

H. E. Eskridge

H. E. Eskridge,
Manager, Nuclear Licensing,
Safety, and Accountability

HEE/sld/9055

cc: George France

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ABB Combustion Engineering Nuclear Power

Combustion Engineering Inc
P O Box 107, Highway P
Hematite, Missouri 63047
Telephone (314) 937-4691
Telephone (314) 296-5640
Fax: Extension 15

ASEA BROWN BOVERI
Telephone
(314) 937-4691
(314) 296-5640
Fax
Ext. 15

Inter-Office Correspondence

July 25, 1991

TO: J. A. Rode

FROM: R. W. Griscom KWG

SUBJECT: Sampling Spent Limestone From The Dry Scrubbers

Summary

Spent limestone was sampled from different levels within a dry scrubber and compared with samples from the bottom of all the dry scrubbers. There was no significant difference between any of the sample locations. Subsequently, samples were evaluated for five months. All samples were within the 30 pci/g release limit and all of the values within three standard deviations of the mean of all the samples are within the release limit.

Sampling Procedure

The sampling of spent limestone when unloading the dry scrubbers into hoppers was accomplished by placing a sample collection container in the hopper lid opening. The hopper was then lifted into place to seal the lid opening against the bottom of the scrubber. The first limestone out of the scrubber filled the sample container and the remaining limestone flowed around the container into the hopper. Since the offgas enters the bottom of the dry scrubber, as shown in Figure 1, this location was felt to provide the best chance to pick up a high sample.

An evaluation of this sampling procedure was conducted in December, 1990. Each of the five dry scrubbers was sampled ten times during normal operating conditions. Four of the scrubbers were sampled with the method described above. The other scrubber was emptied into two 55 gallon drums and samples were taken from the bottom, one quarter up from the bottom, middle, three quarters up from the bottom, and the top of the scrubber.

The samples were spread out to cool and then surface counted with a PAC-4G counter. After counting, the samples were milled in a hammer mill and collected in a vacuum cleaner. A 50 gram sample of milled limestone was submitted to Health Physics. A 0.5 gram sample was counted on the Tennelec counter. The samples were counted for 10 min. and 60 min. The 60 min. counts are presented in Table I.

Data Evaluation

One of the initial objectives was to show that the bottom samples exhibited the highest results. This would then be the most conservative place to sample in order to disposition the spent limestone for onsite burial. As it turned out from the sampling results, the bottom samples are not any higher than anywhere within the scrubbers. The mean value for all the bottom samples was 4.3 pci/g versus 5.975 pci/g for the upper samples.

As noted in Table I, negative data values have been included. These have been evaluated as negative numbers and not zero value to provide a better representation of the full range of values obtained by this method. The reported values are the difference from the background count. The background count is subject to the same system accuracy as the sample count, thus the variability can cause a negative value. The accuracy of the counting method can be expressed as a counting error, which equals 2 times # of counts. This would mean a possible error range of almost ±100% at 0 pci/g to ±17.6% at 30 pci/g. At the sample mean of 5.044 pci/g the counting error is ±43%, or ±2.16 pci/g.

Since it was not evident that the bottom samples were higher, the sample results were compared statistically to determine if there was any significant difference between any of the sampling locations. Table II is a presentation of the range, mean, and standard deviation for each of the sampling locations. The results from the third quarter position in scrubber 2 indicates that this position may have higher results than other positions. Using a standard, two-tailed, t test to evaluate the difference between sample means, each position was compared against all other positions. The results presented in Table III show that there are no significant differences between the sample means. An analysis of variance test was then conducted for the five vertical positions within a scrubber. The results presented on Figure 2 demonstrate that there is no significant difference between the vertical sampling positions. An analysis of variance test was finally conducted for all nine sample positions. The results presented in Figure 3 show there is no significant difference between any of the sampling positions. A t test was run to compare all the bottom samples with the group of upper samples. The result presented in Figure 4 shows that the sample means are essentially the same.

All of the samples were combined to determine the mean and standard deviation which were 5.04 pci/g and 5.886 pci/g respectively. This means that under normal operating conditions, 99.7% of the time the samples will be within the release limit of 30 pci/g.

Subsequent Evaluation

From Dec. 7, 1990 through May 9, 1991, 349 spent limestone samples were taken from the bottom of the dry scrubbers. All of the samples were milled and counted for 60 minutes as described above. A summary of the results is included on Table II. The mean for all samples is 4.65 pci/g with a standard deviation of 3.66 pci/g. This indicates that under normal conditions all of the spent limestone will be within the release limit of 30 pci/g.

Conclusion

All of these tests indicate that there is no significant difference between the samples, thus a sample from any location is a fair representation of the rock within the scrubber. Taking this a step further, the proposed bottom sample is an acceptable location for sampling the scrubbers. The limestone dry scrubbers can be effectively sampled at the bottom while emptying into a bulk unload hopper. Provided the samples are not contaminated during handling, these samples can be milled and counted by Health Physics for subsequent disposition of the limestone. A preliminary surface count with a PAC-4G will avoid putting grossly contaminated limestone through the mill. Samples from upset conditions will enable the isolation of the contaminated spent limestone. This will be the sampling procedure for all subsequent testing of the spent limestone for release.

cc: W. C. Christopher
L. F. Deul
H. E. Eskridge
G. F. Palmer

RWG/91/0092

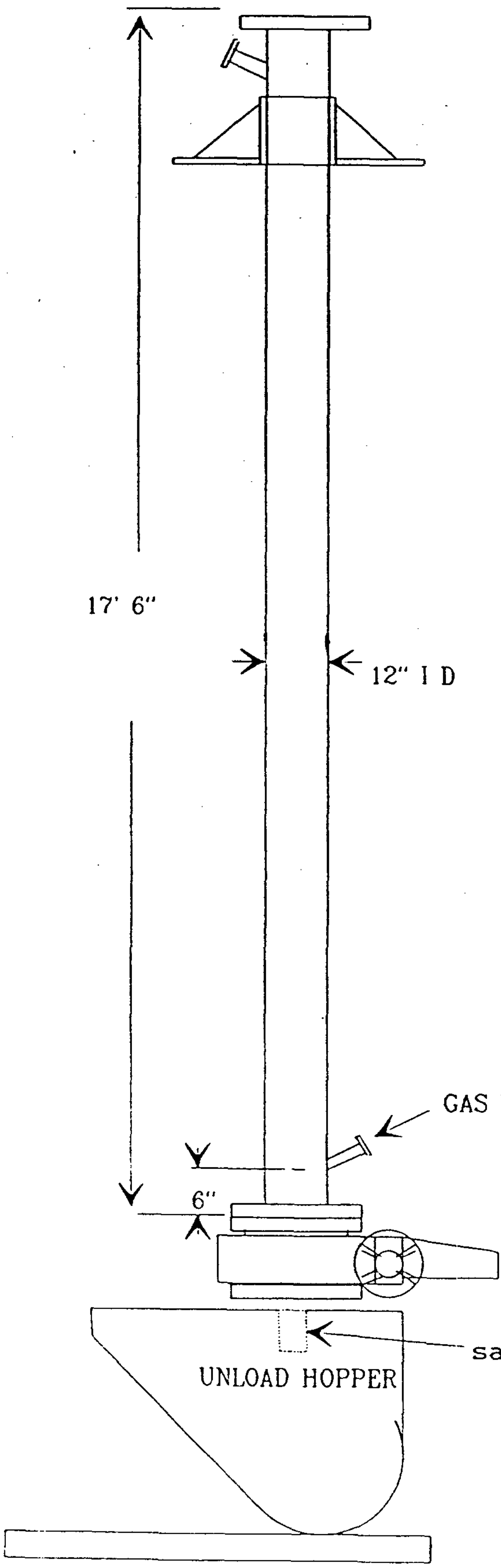

FIGURE 1

LIMESTONE FILLED
DRY SCRUBBER

RWG
1/17/91

TABLE I

DRY SCRUBBER SAMPLES
Tennelec Counter
(60 minute counts, pci/g)

SCRUBBER													
	1	2					3					4	5
Sample	Bot	Bot	1/4B	Mid	3/4B	Top	Bot	1/4B	Mid	3/4B	Top	Bot	Bot
1							6	3	4	4	9	3	5
2	5	1					4	3	3	2	5	5	4
3	7	2					1					5	2
4	4	3	11	1	9	8	4					19	3
5	0	–2	–1	0	–1	2	–1					2	4
6	4	2	2	1	–4	1	7					–1	5
7	4	6					9	2	0	6	26	2	14
8	4	5	11	13	21	4	–3					3	–1
9	20	3	7	4	19	4	1					–1	1
10	6	8	5	0	9	1	6					4	12
11	7	2	5	4	30	6							

Total number of samples = 90
Sample mean = 5.044 pci/g
Sample total = 454
Sample standard deviation = 5.886 pci/g

TABLE II

DATA SUMMARY

Sample Location	Sample Size	Minimum Value	Maximum Value	Sample Mean	Standard Deviation	Standard Error
Bottom 1	10	0	20	6.1	5.28	1.67
Bottom 2	10	−2	9	4.0	3.20	1.01
Quarter 2	10	−1	11	4.8	3.91	1.24
Middle 2	10	0	13	3.0	3.92	1.24
Thquart 2	10	−4	30	9.7	11.16	3.53
Top 2	10	1	26	6.6	7.34	2.32
Bottom 3	10	−3	7	2.4	3.27	1.03
Bottom 4	10	−1	19	4.1	5.65	1.79
Bottom 5	10	−1	14	4.9	4.68	1.48
12/7–12/15/90	35	−1	16	5	4	.68
12/16–1/10/91	35	1	16	6	4	.68
1/11–1/27/91	35	2	18	7	4	.68
1/28–2/7/91	35	1	15	6	3	.51
2/8–2/18/91	35	0	12	3	3	.51
2/19–3/4/91	35	0	10	3	3	.51
3/5–3/24/91	35	0	16	4	3	.51
3/25–4/13/91	34	0	9	4	2	.34
4/14–4/26/91	35	0	10	5	3	.51
4/27–5/7/91	35	0	24	3	4	.68
Clean rock	5	1.4	5.5	3	1.83	.82

TABLE III

t TEST OF SAMPLE MEANS

location	bot 1	bot 2	qrtr 2	mid 2	thqrtr2	top 2	bot 3	bot 4	bot 5
bottom 1	–	1.076	.626	1.490	–.922	–.175	1.884	.818	.538
bottom 2	–1.076	–	–.501	.625	–1.553	–1.027	1.106	–.049	–.502
quarter 2	–.626	.501	–	1.028	–1.311	–.684	1.489	.322	–.052
middle 2	–1.49	–.625	–1.028	–	–1.791	–1.365	–.372	–.506	–.984
thqrtr 2	.922	1.553	1.311	1.791	–	.734	1.984	1.416	1.254
top 2	.175	1.027	.684	1.365	–.734	–	1.654	.854	.618
bottom 3	–1.884	–1.106	–1.489	.372	–1.984	–1.654	–	–.824	–1.385
bottom 4	–.818	.049	–.322	.506	–1.416	–.854	.824	–	–.345
bottom 5	–.538	.502	.052	.984	–1.254	–.618	1.385	.824	–

Ref: Statistics; Sanders, Eng, and Murph; 3rd Ed., McGraw-Hill, 1985

$$CR = \frac{x_1 - x_2}{\sigma_{x1-x2}} \quad \text{where} \quad \sigma_{x1-x2} = \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

x_1 = sample mean
σ_1^2 = sample variance
n_1 = sample size

degrees of freedom = $(n_1 + n_2 - 2)$

Compare CR versus t_{table}, where $t_{18,\alpha=.025} = 2.101$

Accept H_0 if CR is within $\pm$ 2.101

Figure 3
ANALYSIS OF VARIANCE

All samples

Sample	Bottom 1	Bottom 3	Bottom 4	Bottom 5
1	5	1	3	5
2	7	2	5	4
3	4	1	5	2
4	0	4	19	3
5	4	-1	2	4
6	4	7	-1	5
7	4	6	2	14
8	20	-3	3	-1
9	6	1	-1	1
10	7	6	4	12
Σx	61	24	41	49
$\bar{x}$	6.1	2.4	4.1	4.9
std. dev.	5.28	3.27	5.65	4.68

ref: Statistics, Sanders, Eng, and Murph; 3rd Ed., McGraw-Hill, 1985

combining all nine groups of samples: $\bar{\bar{X}} = \frac{456}{90} = 5.07$

$$\hat{\sigma}_b^2 = \frac{10(4.0-5.07)^2 + 10(4.8-5.07)^2 + 10(3.0-5.07)^2 + 10(9.7-5.07)^2 +}{8}$$

$$\frac{10(6.6-5.07)^2 + 10(6.1-5.07)^2 + 10(2.4-5.07)^2 + 10(4.1-5.07)^2}{8} +$$

$$\frac{10(4.9-5.07)^2}{8} = \frac{384.3}{8} = 48.04$$

$$\hat{\sigma}_w^2 = \frac{(3.2)^2 + (3.91)^2 + (3.92)^2 + (11.16)^2 + (7.34)^2 + (5.28)^2 + (3.27)^2}{9} +$$

$$\frac{(5.65)^2 + (4.68)^2}{9} = \frac{311.7}{9} = 34.6$$

$CR_F = \frac{48.04}{34.6} = 1.39$ $\quad df_{num} = k-1 = 8$ $\quad F_{table} = 2.06$

$df_{den} = T-k = 81$

therefore, since $CR_F < F_{table}$ accept H_0: no significant difference between sample means

Figure 4

t Test for Bottom versus Upper Samples

Bottom Group: n= 50 $\bar{x} = 4.3$ $\hat{\sigma} = 4.509$

Upper Group: n= 40 $\bar{x} = 5.975$ $\hat{\sigma} = 7.206$

$$CR = \frac{\bar{x}_1 - \bar{x}_2}{\hat{\sigma}_{\bar{x}_1-\bar{x}_2}} \qquad \text{where } \hat{\sigma}_{\bar{x}_1-\bar{x}_2} = \sqrt{\frac{\hat{\sigma}_1^2}{n_1} + \frac{\hat{\sigma}_2^2}{n_2}}$$

$$= \sqrt{\frac{(7.206)^2}{40} + \frac{(4.509)^2}{50}}$$

$$= 1.306$$

$$CR = \frac{5.975 - 4.3}{1.306}$$

$CR = 1.283$ degrees of freedom = 40+50-2 = 88

$t_{table} = 2.000$

therefore, since $CR < t_{table}$ accept H_0: $\mu_1 = \mu_2$