MOISTURE MONITORS FOR THE TRITIUM EMISSIONS REDUCTION FACILITY

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ABSTRACT

Three types of moisture monitors: MCM Model Dewlux-20, Panametrics Model System One, and Shaw Model SHA-TRS were tested for accuracy and speed of response over low (10-50 ppm H_2O), medium (100-500 ppm H_2O), and high (500-4,000 ppm H_2O) concentration ranges. The results for the three instruments tested (one of each kind) showed that the MCM instrument was generally more accurate and responded more quickly than the other two instruments, with the Panametrics instrument being less accurate (except at low concentration) and slower to respond, and the Shaw instrument was the least accurate and least responsive of the three instruments during the tests made.

BACKGROUND

A knowledge of the amount of water vapor that has passed through various pieces of equipment can be valuable in a tritium capture system, such as Mound's Tritium Emissions Reduction Facility (TERF).¹ The concentration of water vapor in the gas stream and the flowrate determine how much must be removed by the dryers. The integrated amount of water collected indicates how much unused dryer capacity remains on dryers and how much longer they can be used before they must be regenerated.

Because levels of moisture and rates at which these concentrations vary with time are expected to differ widely at different points in the TERF, it might be desirable to use different types of moisture monitors in this system. An evaluation

of different types of moisture monitors was done in order to gain information as to which one would be the best for specific applications in the TERF.

EQUIPMENT

Moisture measurements need to be made against a calibrated standard in order to determine their accuracy. Provision of a standard was done by purchasing a General Eastern Chilled Mirror Humidity Analyzer and having its calibration checked and certified by Dr. John Hartley of the Sandia National Laboratories. This type of device is considered to be quite reliable and is often used as the standard in moisture measurements.^{2,3}

The candidate moisture meters were plumbed in series with the chilled-mirror device. Then readings were taken simultaneously with these instruments in order to get comparisons between them. The three different instruments were tested in the work were:

- 1) an MCM Dewlux-20 Si-Grometer, with 0-100 and 0-1000 ppm (vapor) scales;
- 2) a Panametrics System One; and
- 3) a Shaw Moisture Meter, Model SHA-TRS, with 0-1 and 0-1,000 ppm (vapor) scales.

Each of these types of instruments reads the electrical impedance of an electrode containing a layer of porous insulator between two electrodes. As moisture condenses in the pores, the electrical impedance is decreased. The higher the moisture content of gases to which the probe is exposed, the greater the amount of meter that adsorbs and the lower the impedance reading.^{3,4} The Panametric and Shaw units use a sensor based upon aluminum oxide, while the MCM units use a silicon oxide probe.

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Each of these instruments was new when tested and had been calibrated by the manufacturer. It should be mentioned, however, that only one instrument of each type was used in these evaluations. The variation in results between different instruments of the same type was not tested.

MEASUREMENTS

The tests in this work were done at various moisture levels because the water concentration expected in the TERF varies from percent levels in the regeneration system down to less than one ppm in the system exhaust. Reliable tests are very difficult and time-consuming at low-ppm levels due to adsorption effects. To avoid these problems, the low level tests were done at concentrations well above 1 ppm. The testing procedures used in this work and the results obtained are described below. All results in this work are reported in parts per million by volume (ppm), which is the same as the molar concentration in parts per million.

Tests At Low Moisture Concentrations

The first test was run using a nitrogen gas cylinder as the source of gas. The concentration of moisture in the gas was measured using the General Eastern chilled-mirror system. During the two days of the tests, the moisture concentration decreased from 25 to 12 parts per million by volume. The results of the test including the date,

time, and concentrations measured using the General Eastern, MCM, Panametrics, and Shaw instruments are listed in Table 1.

The data from Table 1 have been plotted in Figure 1 and show a comparison of them. The measurements were all made at discrete times, but are joined in the figure to show a smooth curve in each case, based upon the assumption that the concentration measured changed linearly between the times of the measurement.

None of the three test instruments picked up the initial drop in moisture concentration. The readings of the MCM instrument averaged approximately 40% low. The readings of the Panametrics instrument, with the exception of an excursion upwards during the middle of the run, averaged approximately 50% high. The Shaw measurements were essentially constant and averaged 65% low. None of the instruments did very well in this test, although the MCM instrument was the most accurate of the three, as can be seen by examination of these data as plotted in Figure 1.

Test At Intermediate Moisture Concentrations

In the intermediate moisture level (100-500 ppm) the test was done with moisture concentration. The data from this test are shown in Table 2 and Figure 2.

Table 1 - COMPARISON OF MOISTURE ANALYZERS -
LOW CONCENTRATIONS

Observation No.	Date	Time	Moisture Concentration, ppm			
			Standard	MCM	Shaw	Panametrics
1	11/22/88	0930	25.7	7.2	4.0	22.1
2		0940	18.6	7.2	4.0	21.5
3		0950	14.1	7.3	4.0	21.5
4		1220	13.1	7.2	4.0	20.7
5		1230	13.6	7.2	4.0	20.7
6		1245	13.6	7.1	4.0	21.2
7	11/23/88	0840	13.9	6.0	4.5	26.4
8		1200	12.0	6.9	4.0	23.2
9		1250	11.7	7.0	4.0	19.9
10		1310	11.7	7.1	4.0	19.3
11		1440	11.7	7.2	4.0	18.8
12		1450	11.7	7.2	4.0	18.4
13		1500	11.7	7.3	4.0	18.4
14		1505	11.7	7.3	4.0	18.1

Figure 1 - Comparison of Moisture Analyzers - Low Concentration.

Figure 2 - Comparison of Moisture Analyzers Intermediate Concentration.

Table 2. COMPARISON OF MOISTURE ANALYZERS - INTERMEDIATE CONCENTRATIONS

Observation No.	Date	Time	Moisture Concentration, ppm			
			Standard Generator	MCM	Shaw	Panametrics
1	2/2/89	1020	202	205	140	362
2		1310	216	191	130	369
3		1445	224	186	130	362
4	2/3/89	0630	182	164	120	232
5		0635	184	163	120	232
6		0810	186	163	120	239
7		1225	194	165	120	244
8	2/4/89	1515	195	168	120	237
9		0910	195	169	105	215
10		1105	198	167	105	220

Examination of Figure 2 shows that the MCM readings were the most accurate. Those of the Panametrics instrument were high for the first day, but finally came down to more reasonable levels. The Shaw instrument readings were consistently low.

Tests at Higher Moisture Concentrations

Tests were also run at relatively high concentrations, from 200 to 3,000 parts per million. These data are shown in Table 3, and are plotted in Figure 3.

Table 3. COMPARISON OF MOISTURE ANALYZERS - HIGHER CONCENTRATIONS

Observation No.	Date	Time	Moisture Concentration, ppm				
			Moisture Generator	Standard	MCM	Shaw	Panametrics
1	1/10/89	0630	206	188	190	125	227
2		0635	206	198	190	125	229
3		0640	206	215	190	125	229
4		1523	234	242	202	175	266
5	1/16/89	1600	367	373	415	290	455
6		1606	367	376	415	290	455
7		1615	368	373	414	290	450
8	1/17/89	0620	384	376	363	280	393
9		0637	386	380	364	288	393
10		0647	1721	1897	* *	290	1298
11		1145	2480	2110	"	310	1639
12		1150	2481	2113	"	310	1654
13	1/18/89	0615	1208	1235	"	300	1085
14		1255	1975	1860	"	*	1347
15		1302	2001	1696	"	"	1347
16		1450	2152	1826	"	"	1387
17		1507	3508	2815	"	"	1933
18		1520	3531	2482	"	"	1846
19	1/19/89	0630	2725	2570	"	"	1813
20		1205	3203	1760	"	"	1426

* * MLM System overload above 1000 PMMV

* Shaw did not respond to change in moisture level

Figure 3 - Comparison of Moisture Analyzers - Higher concentrations.

By referring to this figure, we see that the MCM instrument was the best in its agreement at the lowest part of the range. The MCM measurements were low by 8%. The Panametrics measurements tended to be almost as good, being high by an average of 10 percent. The Shaw measurements were uniformly low by an average of approximately 40 percent.

As the readings approached 1,000 parts per million, both the MCM and Shaw instruments ceased to give readings since they were outside their designed region of operation. The Panametrics unit continued to give readings; however, they were considerably lower than those of the standard, in some cases by amounts exceeding 50 percent.

All of these tests were done with normal (protium) water. The water processed in the TERF is expected to contain tritium at concentrations of 100 to 1,000 curies per liter of liquid water. These

concentrations are low enough that the radioactive contribution to the conduction of the absorbed water in the pores of the probe is expected to be not significant. Moisture probes used in such radioactive service at Mound have given readings below 1.0 ppm.

These tests indicated that: (1) the MCM instrument (which is the most expensive of the three test instruments) was generally the most accurate and responded fastest to concentration changes; (2) the Panametrics instrument (an intermediate-priced instrument) was less accurate and slower to respond to changes, except in the low concentration range, but its performance was close to that of the MCM; and (3) the Shaw instrument (the least expensive instrument) was the least accurate and the slowest to respond, but it could be used in some applications where accuracy and speed of response are not critical.

CONCLUSIONS

On the basis of these tests, it was decided to use both MCM and Panametrics instruments at different places in the TERF. The MCM instruments will be used in the first part of the process where the moisture concentrations are the highest and the most variable. The Panametrics instruments will be used for the last half of the process where the moisture concentrations are lower and less variable.

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