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A LOAD-CELL-BASED WEIGHING SYSTEM FOR WEIGHING 9.1- AND 12.7-TONNE UF_6 CYLINDERS*

W.A. McAuley
Martin Marietta Energy Systems, Inc.
Oak Ridge, Tennessee 37831

W.R. Kane
Brookhaven National Laboratory
Upton, New York 11973

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ABSTRACT

For the independent verification of UF_6 cylinder masses by the International Atomic Energy Agency (IAEA) at uranium enrichment facilities, an 18-tonne capacity Load-Cell-Based Weighing System (LCBWS) has been developed. The system was developed at Brookhaven National Laboratory and the Oak Ridge Gaseous Diffusion Plant and calibrated at the U.S. National Bureau of Standards. The principal components of the LCBWS are two load cells, with readout and ancillary equipment, and a lifting fixture that couples the load cells to a cylinder. Initial experience with the system demonstrates that it has the advantages of transportability, ease of application, stability, and an attainable accuracy of 2 kg or better for a full cylinder.

INTRODUCTION

In order to apply International Atomic energy Agency (IAEA) safeguards to low enriched uranium in enrichment and fuel fabrication plants, it is necessary to have independent means of verifying the weights of UF_6 cylinders. In order to satisfy this need, several load-cell-based weighing systems have been developed with the capability of weighing a 30-in. UF_6 cylinder.(1-3) These systems have a capacity of 4.5 tonnes and have been demonstrated to have an accuracy of 1 kg at full capacity. Their portability, ease of assembly and use, accuracy, and stability afford advantages for their use in a wide variety of weighing operations.

THE SYSTEM

In order to provide for the verification of the masses of large-capacity UF_6 cylinders by the IAEA at uranium enrichment facilities, a new, 18-tonne-capacity load-cell-based weighing system (LCBWS) has been developed.(4) The system was developed at Brookhaven National Laboratory and the Oak Ridge Gaseous Diffusion Plant (ORGDP) and calibrated at the U.S. National Bureau of Standards (NBS). The principal components of the system are shown in Figure 1. Since the system was intended for use with the 20-ton double-hook overhead bridge cranes installed at the GCEP Feed and Withdrawal Building, it consists of two "branches", each employing a load cell with 10-ton readout capacity and associated lifting hardware (shackles, eye nuts, threaded connecting rods, and flexures). The flexures, which behave as perfect pivots, are situated above and below the load cells to insure that there are only axial forces on the load cells, since non-axial forces tend to degrade the accuracy of the measurement. Situated below the two load-cell branches is a lifting fixture which provides a coupling with the UF_6 cylinder being lifted. The change in resistance of each load cell, proportional to the force exerted on it, is sensed by transducer indicators which provide a digital readout closely proportional to the applied force. The load cells and transducer were calibrated together previously directly in units of force, and the temperature dependence of the response determined. The stability of the system is verified independently by a standardizer which simulates the response of the load cell. Small corrections for temperature and system drift are applied to the load-cell indicator values to obtain the applied force for each load cell from the NBS calibration, and the sum of the two forces, with appropriate corrections for the local acceleration due to gravity and air buoyancy, provides a mass value to be compared with the mass determined by the facility scales.

A small, on-line computer has been added to the system which accepts the digital data from the transducers, performs the indicated calculation, and provides a value for the cylinder mass and a summary of calibration and correction data. This feature not only eliminates the need for the operator to perform the calibrations but also gives the cylinder mass immediately after the weighing operation.

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RESULTS

In an initial evaluation program at the ORGDP, the performance of the system was tested in a repetitive series of weighings of 9.1- and 12.7-tonne UF_6 cylinders and of one 9.1-tonne replica mass standard. The results of these measurements are compared with the facility mass values in Table I. An analysis of the results, combined with the known uncertainties in facility mass values, indicates an average bias of 1 kg between the two sets of measurements and an overall accuracy of 2 kg or better for the LCBWS, which is quite sufficient for its intended use in verifying declared facility masses of UF_6 cylinders.

Recently, after a recalibration of the load cells and transducers, a new series of weighings, similar to the first, was performed. The values obtained for bias and accuracy were comparable or better than those obtained earlier.

CONCLUSION

The system, although considerably more massive than the earlier 4.5-tonne systems, is readily transportable and straightforward in its application, with the weighing of a cylinder requiring, typically, about 15 minutes. The relative ease of operation, stability, and accuracy of the large LCBWS suggest that it may constitute a useful alternative, in favorable circumstances, to existing facility weighing systems.

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PROTOTYPE SYSTEM CONFIGURATION

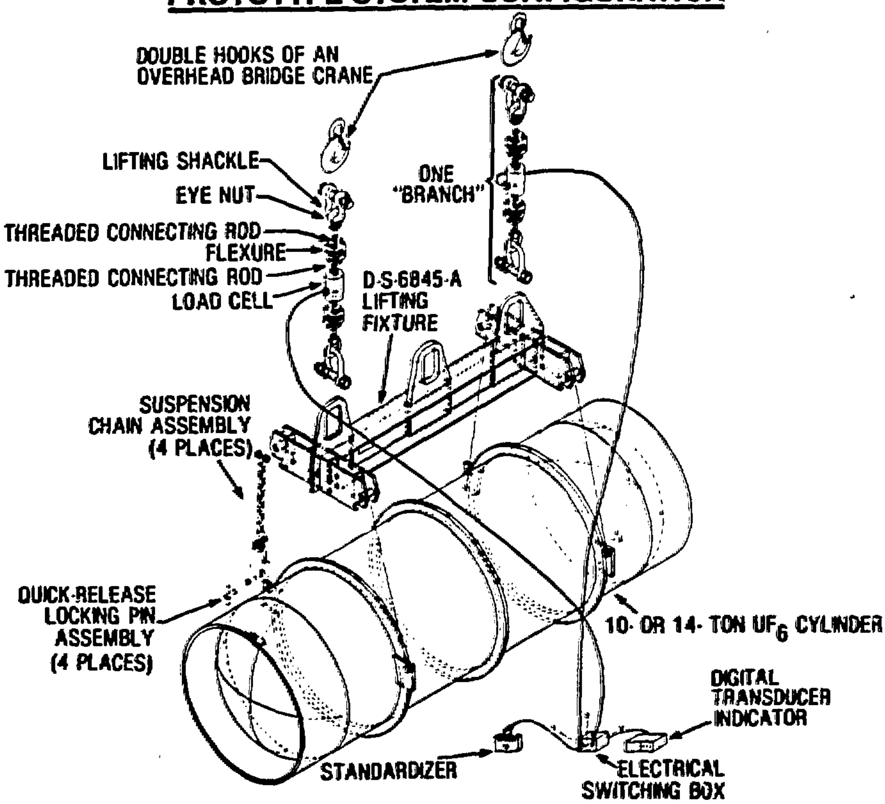

Figure 1. Exploded view of Load-Cell-Based Weighing System

Table I
Results of Load-Cell-Based Weighing System Test

Cylinder Number	Facility Mass Value M_o(kg)	Load Cell Measurement M_L(kg)	M_o-M_L (kg)	(M_o-M_L) Bias (kg)	σ(Bias) (kg)
<u>9.1 Tonne</u>					
Replica Mass Standard	11,748	11,750.9	-2.9		
		11,747.9	0.1		
		11,749.3	-1.3	-0.42	1.13
		11,745.6	2.4		
KM401	11,506.7	11,503.1	3.6		
		11,503.6	3.1		
KM1867	11,532.6	11,529.2	3.4		
		11,529.5	3.1		
KM1663	11,521.3	11,518.7	2.6	2.43	0.70
		11,516.3	5.0		
KM1516	11,446.4	11,443.6	2.8		
		11,442.7	3.7		
KM409	11,539.9	11,540.6	-0.7		
		11,542.2	-2.3		
<u>12.7 Tonne</u>					
UK1122	14,836.6	14,834.2	2.4		
		14,833.5	3.1		
UK1207	14,494.1	14,497.1	-3.0		
		14,495.1	-1.0		
UK1233	14,560.3	14,564.1	-3.8		
		14,560.0	0.3		
				0.93	0.85
UK1237	14,534.5	14,530.9	3.6		
		14,527.8	6.7		
UK1239	14,507.3	14,507.7	-0.4		
		14,507.8	-0.5		
UK1232	14,843.8	14,842.1	1.7		
		14,841.7	2.1		