THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV

U.S. Environmental Protection Agency

SOUTHERN RESEARCH INSTITUTE

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**Refrigerant Leak Monitoring Device**
APPLICATION:	**Refrigeration and Air Conditioning Equipment**
TECHNOLOGY NAME:	**KMC SLE-1001 Sight Glass Monitor**
COMPANY:	**KMC Controls, Inc.**
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The U.S. Environmental Protection Agency (EPA) has created the Environmental Technology Verification (ETV) program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV program is to further environmental protection by substantially accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer reviewed data on technology performance to those involved in the purchase, design, distribution, financing, permitting, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations, stakeholder groups that consist of buyers, vendor organizations, and permitters, and with the full participation of individual technology developers. The program evaluates the performance of technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests, collecting and analyzing data, and preparing peer reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated, and that the results are defensible.

The Greenhouse Gas Technology Center (GHG Center), one of six verification organizations under the ETV program, is operated by Southern Research Institute, in cooperation with EPA's National Risk Management Research Laboratory. The GHG Center has recently evaluated the performance of the SLE-1001 Sight Glass Monitor (SGM) which is offered by KMC Controls, Inc. of New Paris, Indiana. This verification statement provides a summary of the results obtained during testing of the SGM.

TECHNOLOGY DESCRIPTION

The transfer of heat in refrigeration and air-conditioning systems is performed by a refrigerant operating in a closed system. Most systems use hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) as refrigerants. These chemicals have high global warming potentials and extremely long atmospheric lifetimes. In the upper atmosphere, HCFCs and HFCs contribute to the destruction of Earth's protective ozone layer. Although these refrigerants are maintained in closed systems, some of the refrigerant escapes to the atmosphere during routine installation, operation, and servicing of the equipment. In addition, fugitive emissions escape into the atmosphere from leaky components, resulting in further refrigerant loss.

To determine if a cooling system is charged with sufficient refrigerant, a sight glass is installed in the liquid line to allow visual inspection of the refrigerant condition. Most commercial and industrial equipment is manufactured with a sight glass near the condenser outlet. A clear liquid in the sight glass indicates that there is adequate refrigerant charge in the system to ensure proper feed through the expansion valve. Bubbles in the sight glass can indicate the presence of refrigerant vapor or noncondensables in the liquid line. A continuous presence of bubbles during compressor operation indicates that the system is short of refrigerant charge, which can be an indication that refrigerant is leaking from the system.

The KMC SLE-1001 Sight Glass Monitor (SGM) is designed to measure and interpret the condition of the refrigerant in the sight glass. It provides operators with visible alarms, while optional programmable controllers can transfer these alarms and other data to remote building operating systems. The SGM is an external device that is mounted on an existing Sporlan® sight glass. Using infrared radiation emitters and detectors, the SGM continuously monitors for the presence of bubbles and/or moisture in the refrigerant. When bubbles or flash gases of noncondensed refrigerant are detected in the sight glass, a red light-emitting diode (LED) on the monitor housing flashes. The frequency of the red LED pulses increases with increased frequency of bubble detection. A moisture LED on the monitor housing changes from green to yellow when moisture is detected in the system. As moisture levels increase, the LED glows brighter in proportion to the degree of moisture detected. In both cases, the SGM provides a 0- to 5-V output, with the voltage increasing proportionally to the red LED flash frequency and the yellow LED intensity.

In this verification, the SGM was connected to a voltage-controlled relay and timer/annunciator. The timer/annunciator was set to trigger an audible and visible alarm when the SGM output was greater than 4.0 VDC for more than 1 minute. This alarm notified the equipment operator of a low refrigerant charge condition, and the possible presence of a refrigerant leak. Alternatively, the 0- to 5-V SGM output signal can be wired to the optional KMDigital Controller, which, in turn, can be connected to computerized building automation systems. The KMDigital Controller was not a part of this verification.

VERIFICATION DESCRIPTION

Verification of the SGM was designed to characterize, via measurements and other means, the following verification parameters:

- SGM Installed Cost
- SGM Leak Detection Sensitivity
- Potential Refrigerant Savings

Verifications of each of these parameters were conducted at two typical commercial buildings located on the North Carolina State University (NCSU) campus in Raleigh, North Carolina. Details of the verification test design, measurement test procedures, and Quality Assurance/Quality Control (QA/QC) procedures can be found in the Test Plan titled *Test and Quality Assurance Plan for the KMC Controls, Inc. SLE-1001 Sight Glass Monitor* (SRI 2001). A Carrier commercial-scale roof-top air-conditioning system and a reciprocating chiller, both owned and operated by NCSU's Centennial Campus, were selected to evaluate the SGM. The test systems are representative of the types and sizes of commercial-scale systems to which KMC plans to market the device. Both systems use HCFC-22 (R-22) refrigerant and are equipped with dual compressors and refrigerant circuits. The SGM was installed on one of the two compressor circuits on each system. Nominal refrigerant capacities of the rooftop HVAC system and the reciprocating chiller are 64.5 and 70 lb, respectively. Nominal cooling capacities are 75 tons for the rooftop HVAC system, and 70 tons for the chiller unit.

Capital costs were verified by obtaining SGM and timer/annunciator prices from KMC. A certified technician installed new Sporlan® sight glasses on each test unit to meet KMC's requirements for vertical orientation and clean sight glass condition. Costs for this work were obtained from the technician's invoices. A professional heating, ventilation, and air-conditioning (HVAC) service organization (Brady Services, Inc.) estimated the cost for associated wiring and conduit necessary to permanently install the SGM and timer/annunciator on site.

The definition of refrigerant leak detection sensitivity is the percentage of full charge removed or leaked at which the SGM will detect low refrigerant levels and sound an audible and/or visible alarm. To verify this parameter, the GHG Center measured the full charge of each test compressor, then systematically drew out an incremental quantity of refrigerant until the SGM and timer/annunciator produced an alarm condition. A digital scale was used to measure and record refrigerant additions and withdrawals. The ratio of the weight of refrigerant withdrawn at the point of monitor alarm divided by the weight of full charge times 100 represented the SGM leak detection sensitivity.

The verification also estimated potential refrigerant savings associated with the use of the SGM. Records documenting the results of standard industry practice service events (dates, amount of lost refrigerant replaced) were obtained for the two test units, and for five similar units installed at the NCSU campus. These historical records served as a basis for determining the number of services performed on each unit and the amount of refrigerant added during each service event. Potential savings with the SGM for each service event were computed by estimating the amount of refrigerant that would have been saved if the SGM had warned of losses more rapidly than currently used practices, and an operator had repaired the leaks immediately after each SGM alarm condition. The sum of all potential savings at a particular unit, divided by the number of years in the available records (from 1 to 4 years), provides an estimate of the potential average annual savings.

VERIFICATION OF PERFORMANCE

SGM verification occurred between July 25 and 28, 2001. KMC supplied and installed the SGM and the timer/annunciator on the two test units immediately before testing commenced. NCSU personnel conducted system evacuations, leak checks, and initial charging procedures on both systems immediately prior to the leak detection sensitivity testing. The GHG Center conducted five test runs at each unit, and observed and documented all testing activities. The results of the verification tests conducted on both systems and the SGM installation requirements are summarized below.

Verification tests had been planned at a supermarket-type freezer unit. However, at the beginning of the test runs, the unit was found to be equipped with a head-pressure flooding-control valve. Under the ambient conditions encountered during the tests, this valve prevented bubbles from reaching the sight glass even under very low charge conditions, so detection was not possible with the SGM. KMC determined that the SGM technology as it is currently designed cannot operate in conjunction with such valves, so the Center halted testing on that unit.

SGM Installed Cost

- Total installed cost of the SGM as tested with a timer/annunciator on a system with an existing clean and properly oriented sight glass is approximately $530.00. If a new sight glass is required or if the existing sight glass must be reinstalled in the proper orientation, the SGM costs increase to $768.50.

Leak Detection Sensitivity

- Following manufacturer specifications for fully charging the refrigeration systems (i.e., adding refrigerant until visual observation shows a clear sight glass), the average leak detection sensitivities of the SGM on the roof-top HVAC and chiller systems were 5.09 ± 1.01 and 3.56 ± 0.88 percent of full charge, respectively. These values correspond to average refrigerant losses of 2.64 and 1.66 lb, respectively, on the two systems.

- KMC proposed an alternate method of charging refrigeration systems. In that method, refrigerant is added until the KMC SGM voltage output registers ≥ 4.0 VDC for less than 15 seconds in any 5-minute period. This charging method can often result in bubbles remaining in the sight glass. Nevertheless, if industry accepts KMC's charging methods, and they are applied to the two systems tested, leak detection sensitivities for the rooftop HVAC and chiller units are reduced to 2.22 and 0.55 percent, respectively.

Estimation of Potential Refrigerant Savings

- The estimated potential refrigerant and refrigerant cost savings for the tested rooftop HVAC and the reciprocating chiller units were 7.8 lb ($29) and 137.3 lb ($515) per year, respectively. This is based on the current $3.75/lb price for R-22. The reader is cautioned that these savings are based on a limited data set and population of refrigeration systems, so savings for other installations could vary significantly.

- Maintenance records for four additional rooftop HVAC units and one additional chiller unit were obtained. The estimated potential refrigerant and cost savings for the four rooftop HVAC systems ranged from 0 lb ($0) to 8.8 lb ($33) per year. The estimated potential saving for the additional chiller was 49.3 lb ($185) per year.

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