Test Report

Testo Digital Refrigeration System Analyzer

by Norbert Ludwig and Istvan Nyul

Picture: Students of Open Trade Training Centre conducting practical tests with the Testo refrigeration system analyzer

Foreword:

In May 2007, the Open Trade Training Centre (OTTC) South Africa, received a testo 560 refrigeration system analyzer. This analyzer was given to us by testo's distributor in South Africa, unitemp cc. The purpose was to analyze its functionality within the classical service field of a mechanical manifold as well as the newly available functionalities due to the integrated computer based measuring technology. We would like to thank unitemp for this opportunity.

The report does not go into detail when comparing functionalities with the commonly known mechanical manifolds. These "traditional" features of a manifold are all included in the testo 560. The report focuses, instead, on the improvements and advantages in using the testo 560 instead of an ordinary manifold. Newly available applications and measuring tasks are also discussed.

Dersley/ Springs, South Africa in August 2007

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1. *Digital and analogue displays*

While the traditional "manifolds" generally have analogue displays, the Testo instrument is equipped with a large, easily legible and well lit digital display. Although the general advantage of analogue displays is that changes in readings are easier to pick up, as the values being measured (generally evaporation and condensation temperature) are not, as a rule, subject to sudden change.

The advantages of digital displays lie in the higher resolution and in the exclusion of classical readout errors such as parallaxis errors when looking at an analogue display from an angle. Furthermore, the common problem of temperature being linked to pressure in the wet steam range is solved. While traditional manometers have a maximum of 3 or 4 temperature scales, difficult to read at that, for different refrigerants, the steam tables for all standard refrigerants are stored in the Testo instrument such that there can be no confusion.

Very good conventional service manometers are fitted with instruments of quality class 1. This means that the absolute measuring error (= class error) is 1 % of the limit value of the measuring range. Consequently, the relative measuring error increases for small deflections of the pointer, which can be explained physically by the greater effect of the bearing friction for smaller motive forces of the pointer. An example can serve to illustrate this:

If a class 1 manometer with a 10 bar measuring range is showing 10 bar (= full deflection of the pointer), the absolute error is +/- 0.1 bar, which means that the true value is between 9.9 bar and 10.1 bar. The relative error, in relation to the displayed value, is therefore exactly +/- 1 %. However, if the same instrument is showing 1 bar, the relative error for the same absolute error is +/- 10 %, as the true value is now between 0.9 bar and 1.1 bar. The digital display again offers crucial advantages, as the relative error always remains the same (just as small).

2. *Switchable units*

The SI units are Pa (Pascal) for pressure and K (Kelvin) for the thermodynamic temperature. The problem for many practitioners, who often already have to contend with fractions or multiples of basic units such as"milli", "hecto", "kilo" or "mega", is that a number of non-SI units such as °C, °F, bar, PSI or microns (μm_{Hg}, µ for short) are also used in refrigeration engineering and air conditioning, just to confuse matters even further. This problem has also been solved very impressively here with microcomputer-aided measurement technology: the display units can be changed in the instrument setup.

3. *Absolute pressure vacuum measurement*

A good vacuum is imperative both for the measuring instruments and the system in order to exclude effects from non-condensable foreign gases and moisture on the refrigerant circuit and oil. Whereas in the past when chlorinated refrigerants were used in combination with mineral oil, 10 mbar corresponding to 7,500 MICRONS was considered satisfactory. It should now be possible to reach a final vacuum of 1 mbar corresponding to 750 MICRONS with chlorine-free refrigerants and using special synthetic polymer oils such as polyol ester, polyalkyl benzene, poly-alpha-olefin or polyalkylene glycol.

Many practitioners assess a vacuum using only the standard low-pressure manometer. However, the vacuum range of -1 bar_{eff} (on the basis of absolute vacuum) to 0 bar_{eff} (on the basis of air pressure) is only a few millimetres wide. How therefore do we propose to resolve just 1 mbar, one thousandth of this range? It is not possible! A special vacuum measuring instrument, together with a manifold, is therefore indispensable.

Such a measuring method is built into the Testo instrument. This saves not only the additional costs, but also valuable working time that would otherwise have to be spent on reconnecting, re-evacuating etc. A trend display that indicates in vacuum mode whether the pressure is falling, staying constant or rising is also extremely practical. This makes it easier to assess both the tightness of the system and any moisture that may be present in the circuit.

4. 4-valve Manifold with illuminated sight glass

Only a small percentage of the manifolds used in the field have a 4-valve block; however, this type of valves blocks saves vital working time. The engineer and technician can thus connect a refrigerant bottle and the vacuum pump to the system at the same time as the high- and low-pressure valves without releasing refrigerant into the air unnecessarily or running the risk of letting air and moisture into the system. This allows simultaneous evacuation of all hoses and the system as well as measuring, charging, etc. without fiddly reconnections and re-evacuation of the hoses.

The sight glass with background lighting has proved to be a particularly useful feature. It allows a reliable assessment of the fluid/vapour/oil compared to the standard transflective sight glasses both for filling refrigeration systems with fluid (a must, incidentally, for zeotropic refrigerant mixtures of Ashrae nomenclature R4xx) as well as for recovering of refrigerant, including in poorly lit environments.

5. Database of the thermodynamic properties

The link already mentioned between temperatures and pressures in the wet steam range requires a number of corresponding temperature scales for analogue manometers. These scales are, therefore, always incomplete and also difficult to read in the field. Thanks to the internal database of steam tables for all standard refrigerants, all that must be done on the Testo instrument is to select the refrigerant in the setup.

Pressures and the corresponding temperatures can thus be displayed with the elimination of readout errors. If, as is likely, new refrigerants or mixtures are developed and established, a simple software update is sufficient to adjust the instrument to the new requirements.

6. *Temperature probes, pressure probes, remote probes & calculating displays*

Completely new compared to the conventional manifold is the possibility of connecting additional external temperature and pressure probes. Remote probes can also transmit to the Testo instrument via wireless radio transmission. The available radio transmitters thus practically allow the connection of standardized temperature sensors such as type PT100 or thermocouples. For the first time ever, it is therefore possible, for example, to directly display unique system parameters such as **superheat** and **subcooling**.

While in the past, measuring superheat, for example, also required a thermometer and a calculation of the temperature difference. It is now all done by one instrument with the elimination of possible errors. This consequently opens up new possibilities for diagnostics as well. Up to now it has not been possible to record superheating over a longer period of time by means of conventional instruments. The facilities for connecting refrigerant scales and clip-on ammeters have expanded the diagnostics and made commissioning, charging and evacuating the system easier.

Problems in closed loop controlled systems can thus be diagnosed perfectly (such as the undesired temperature fluctuations when having disadvantageous delay/ response time conditions within the system, resulting in small phase and gain margins of the numerous multi-loop control systems in refrigeration and air conditioning systems). This can be remedied using practical, empirical methods such as the Ziegler-Nichols method, as the "pedestrian" method of recording the parameters manually (often extremely time consuming due to the big thermal response times), is no longer necessary. Similarly, the complex theoretical analyses such as the determination of the Hurwitz and Nyquist criteria, which often fail anyway when there are unknown parameters in the transfer elements and the unknown polynomials of the transmission functions that result, can be omitted.

7. Log functions and slave mode

All the parameters to be calculated that we have mentioned can not only be displayed directly on the PC but can also be stored by the Testo instrument independently for evaluation at a later date. Long measuring periods and intervals can be defined and set for this. This therefore offers a good diagnostic tool for drifts and drop-outs, which perhaps only occur once every few days.

If the instrument is operated in slave mode, connected directly to a laptop, key system parameters can also be shown graphically and in realtime and tracked directly online. This opens up interesting possibilities for commissioning systems whereby all the key parameters can be read out directly and from one place. Similarly, changes as a result of setting adjustments (eg. a change in the filling amount, a change in the thermal load etc.) can be monitored directly in real time.

8. Facility for recording and exporting data

All measurement data obtained can be processed using the Testo EasyKool software and can also be exported to the usual MS Office applications. This has opened up options to specialist businesses and engineering companies for the first time that have long since already been in use in electrical engineering and industry. For instance, the commissioning engineer can now print out a protocol directly or request it as a file, giving the designer irrefutable documentation of the actual operating parameters of the system.

If routine work is carried out in the context of maintenance agreements, the system status before and after maintenance can virtually be recorded at the push of a button. Both the customer service provider and the end customer can thus be provided with evidence of the success and efficiency of a regular service.

Administratively, the software allows extremely easy creation and updating of individual databases for numerous customers in which various systems can again be assigned to each one. These databases with electronically generated protocols are invaluable in the event of subsequent disputes, guarantee or warranty claims on the part of the customer. Where necessary they can provide retrospective proof that the system conformed fully to the customer's specifications on handover and was perhaps damaged by unauthorized interference or improper handling at a later date.

Conclusion:

An instrument such as the testo 560 refrigeration system analyzer is the ideal instrument for any service technician, maintenance technician or even system engineer operating within the refrigeration and air-conditioning industry. This instrument takes the normal functionalities of a common mechanical manifold and ads a great number of features, applications and possibilities to it. The report function is a unique feature for commissioning and fault finding report purposes.