Keith Shuttleworth
&
Associates Limited

STEAM QUALITY TEST KIT
SQ1T

Set Up And User Guide

Steam Quality Test Kit SQ1T

User Manual 2.0 ENG

Acknowledgements to EN285

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Introduction

Thank you for choosing the Keith Shuttleworth & Associates Ltd Steam quality kit. This kit was developed through extensive practical experience and has been designed to provide reliable and consistent results that conform to the requirements of EN285.

The non-condensable gas test has been designed to be more robust than the standard equipment and also less dependent upon the skill of the operator. It will be found it will provide results that are more consistent than the EN285 method.

The dryness test equipment is similar to that described in EN285 but has been modified to make it more robust. If the calculation disk provided by Keith Shuttleworth & Associates Ltd is used, results identical to EN285 will be obtained. The superheat test equipment is identical to that in EN285.

Warning

Before conducting any tests the contents of this manual must be studied in depth and any associated hazards considered. It is stressed that the test methods are defined in EN285 and not by the authors of this manual, and that the current versions of these documents are the primary references. Sterilizer plant rooms are potentially hazardous areas and the tests involve working on live steam. It is assumed by the authors of this manual that staff conducting steam quality testing will be trained and understand the potential dangers involved with respect to burning, due to contact with either steam or hot surfaces or any other related hazards.

Warranty

The Keith Shuttleworth & Associates Ltd Steam Quality Test Kit is designed and manufactured to the highest standards, using top quality materials. A one year parts only warranty applies from the date of delivery to the customer. The warranty does not apply to abuse or misuse of the equipment, or its use outside of the operating parameters defined within this manual.

Additional Equipment Requirements

To enable you to complete the steam tests, additional equipment is required.

1. Two temperature sensors and indicator/recorder capable of measuring over a range of ambient water temperature to maximum steam supply temperature (Typical O - 150°C). The sensor used for the superheat test should not exceed 4mm diameter.

2. A balance capable of measuring up to 2Kg with 0.1 g discrimination.

3. One or two buckets or other water storage container. A permanent water supply may also be used.

4 A mains power source (if pump supplied is used).

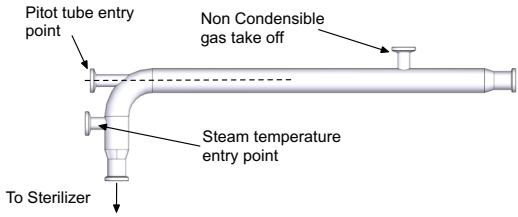
5. A supply of cold water

Steam Test Points

In order to test the steam quality specific test points on the steam line are required.

Fig 1 Illustrates the location of the three test points on the steam supply pipe and they are fitted between the steam distribution system and the sterilizer. It is expected that the pressure at this point would be 2-5 barA (30 – 75 psiA).

Fig 1

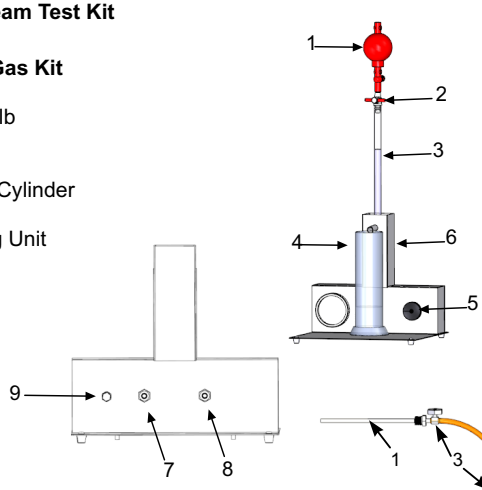


It is important the pitot tube entry point is level and parallel with the steam pipe as any deviation towards the edge of the pipe can influence the results detrimentally.

Assembling the Steam Test Kit

Non-condensable Gas Kit

1 Burette Suction Bulb
2 Burette Cock
3 Burette
4 250 ml Measuring Cylinder
5 Steam Valve
6 Steam Condensing Unit
7 Cooling Inlet
8 Cooling outlet
9 Steam Inlet



Dryness Kit

1 Pitot Tube
2 Rubber Tube
3 Tube Clamps (Optional)
4 Rubber Bung and Tubes
5 Flask

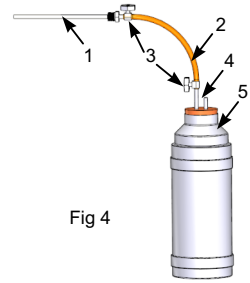
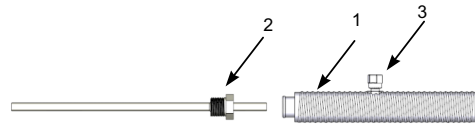


Fig 4

Superheat Kit

1 Superheat Tube
2 Pitot Tube
3 Temperature Probe Entry Gland



The Cooling Pump

To condense the steam in the non-condensable gas-testing unit a supply of cold water is needed. Due to the difficulty that is often found in finding a supply of water in a sterilizer plant room, a cooling pump has been included in this kit.

The unit is a 12 volt, 50 Hz or 110V, 60 Hz, alternating current pump that needs to be totally submerged in water. It is recommended that the pump is used with a residual current safety device

There are two methods of utilizing this pump unit.

1. The unit may be placed in the make-up tank of the sterilizer or other convenient water reservoir.

2. Alternatively, place the pump unit in a bucket of water. There should be enough water in a standard bucket to enable testing to continue for approximately 10 ~15 minutes before replacement of the water, with cold is required.

Do not place the pump in a make-up tank that re-circulates its water, as the fluctuating temperatures could make obtaining a consistent condensate temperature difficult and damage to the pump may occur.

In a tank that has silt or other debris, it is recommended that a filter be fitted.

Warning
Do not let the pump unit run dry as damage to the pump may occur.

Non-condensable Gas Test

Setting up

1. Assemble equipment together as illustrated in Fig. 2. Place on a level surface. Check that the Steam Valve on the test equipment is fully closed and the cooling water valve is fully open.

2. Connect the cooling water supply pipe to the pump at one end and the Cooling Water inlet on the condensing unit at the other (Fig. 3). Connect another pipe from the Cooling Water Outlet to drain or the water source return. Place the pump unit in a suitable water source. If desired the pump unit may be omitted and the water feed connected to a more permanent source. Please note that the water from the Cooling Water Outlet may be very hot and care should be taken to ensure that it can run to

drain unimpeded and without spillage.

3. Isolate the steam supply and after checking that no residual pressure is present, connect the steam supply hose to the non-condensable gas take off point (Fig. 1). Take care, as the steam pipe may be hot and residual steam may be present. Connect the other end of the steam hose to the steam connection of condensing unit (see Fig. 3) and turn the steam supply back on. Warning the steam pipe hose will be hot.

Warning
Do not block or impede the flow of cooling water. The cooling water outlet has to be kept clear.

Performing the Test

1. Before starting the test ensure the steam valve is closed.

2. Turn on the water supply by supplying power to the pump. After ensuring that the cooling water is leaving the outlet pipe, the main steam valve may be slowly opened to a minimal extent (cracked). Live steam and boiling water could discharge from the condensate collecting chamber if insufficient cooling water is available and present a hazard. In any event, precautions should be taken. Do not look into the collecting chamber and wear eye protection.

3. Slowly open the steam valve and by reducing or increasing the flow through the valve, obtain a flow of condensate that will give a temperature of below 70°C, as indicated on the dial temperature gauge. There is no minimum temperature.

4. Fill the condensate collection chamber with water either by filling with water from an external source, or allowing condensate to accumulate.

5. Open the burette cock and draw up condense into the burette with the rubber suction bulb provided, to get a water level near the top. Remember to isolate the burette from the rubber bulb by shutting the burette cock before testing commences.

6. Fill the condensate collection chamber with more water, until it overflows.

7. Ensure that the sterilizer chamber is empty except the normal furniture etc. Select a porous load/equipment cycle and start a run.

8. When the steam supply to chamber first opens, ensure the measuring cylinder is empty, by emptying it.

9. Zero or make a note of the water level in the burette.

10. Any non-condensable gases present in the steam being sampled will rise to the top of the burette. The overflow formed by the condensate and the water displaced by the gases, will collect in the measuring cylinder.

11. When at least 100ml of condense has been collected in the measuring cylinder note

the volume of gas collected in the burette (V_G) and the volume of water collected in the measuring cylinder (V_c).

12.Calculate the amount of non-condensable gases as follows in ml per 100 ml of collected condensate using the following formula:-

$$C_{NCG} = \frac{V_G}{V_C - V_G} \times 100$$

C_{NCG} = Content of Non-condensable gases, in ml per 100 ml condensate from steam
V_G = Volume of water displaced from the burette, in ml
V_C = Volume of water collected in the graduated cylinder, in ml

Acceptance Criteria

The test should be considered satisfactory if the level of non-condensable gases does not exceed 3.5 ml of non-condensable gases per 100 ml of collected condensate.

The test should be done at least three times and the maximum result shall comply with the requirements specified.

Dryness Test

Setting up Assemble the apparatus as per Fig. 4

Isolate the steam supply and after checking that no residual pressure is present, insert a temperature sensor entry gland into the fitting on the steam pipe. The steam pipe may be hot and precautions should be taken against both burning and the presence of residual steam. The temperature probe should be at the geometric center of the steam pipe. Insert the appropriate size pitot tube (see Table 1 below for the correct size and read the note below) into the steam supply. Turn the steam supply back on, taking the necessary precautions against burning/scalding from the steam that will issue from the pitot tube.

Table 1	Steam Pressure (barA)	Up to 3	Up to 4	Up to 7
	mm	0.8	0.6	0.4

Note - Important!
Analysis of the Dryness Value calculation shows that while it takes account of the heat gain by the test equipment, it does not allow for heat losses to the environment which increase with increasing test duration. The longer the test proceeds, the greater the adverse impact on the test result (lower dryness value results). The test duration is affected by the starting volume and temperature of the water in the flask, together with the steam supply pressure and the size of pitot tube used. Our experience is that tests of a short duration are less affected by this effect and we strongly recommend the use of a 0.8 mm pitot tube up pressures of 5 barA and the 0.6 mm size for higher pressures. NB. This approach minimises the unaccounted for losses and does not/cannot provide an artificially high test result.

Performing the Test

1. Weigh the whole assembly including pipe and clips and note the mass in kg (Me).
2. Remove the stopper and tube assembly and pour 650 +/50 ml of cold water (below 27°C) into the flask. Replace the stopper and tube assembly, weigh the flask and

record the mass in kg (Ms).

3. Support the flask close to the pitot tube taking care to avoid the issuing steam. Ensure that the rubber tube and flask are protected from excess heat and draughts. Do not connect it to the pitot tube yet.

4. Introduce the second temperature sensor through the shorter of the two pipes into the water in the flask. Agitate the flask and note the temperature of the water in the flask (To).

5. Ensure the sterilizer is empty except for the usual chamber furniture. Select and start a porous load/equipment cycle.

6. When the steam supply valve to the chamber first opens, connect the rubber tube to the pitot tube. This will require the tester to be in close proximity to the steam issuing from the pitot tube and extreme care is required to avoid scalding and/or burning. Gloves, overalls and eye protection must be worn.

7. Observe/record the steam temperature for the duration of the test and on completion of the test calculate the average temperature (T3).

8. When the temperature in the flask is approximately 80° C, disconnect the rubber tube from the stainless steel tube taking the same precautions as when fitting. Agitate the water in the flask to make sure it is thoroughly mixed. Note the temperature of the water (T1).

9. Remove temperature probe and weigh the flask and stopper assembly including pipe and clips and note the mass in kg (M_f)

10.Calculate the dryness value by using the following formula.

$$D = \frac{(T_2 - T_1)\left[C_{pw}(m_s - m_e) + A\right]}{L(m_f - m_s)} - \frac{(T_3 - T_2)\,C_{pw}}{L}$$

Where:

L = Latent heat of dry saturated steam at temperature T_3 (kJ/kg) see Appendix 1
M_e = The mass of vacuum flask and rubber stopper assembly, pipes and tube in kg
M_s = The mass of vacuum flask, water charge, rubber stopper assembly, pipes and tube in kg
M_f = The mass of vacuum flask, water charge, condensate, rubber stopper assembly, pipes and tube in kg
T_1 = Initial temperature of the water in the vacuum flask in degrees Celsius
T_2 = Final temperature of the water in the vacuum flask in degrees Celsius
T_3 = Temperature of saturated steam delivered to the sterilizer in degrees Celsius
C_{pw} = Specific heat capacity of water (4.18 kj/kg · K)
A = The effective heat capacity of the apparatus (0.23 kJ/K).

If a computer-spreadsheet is to be used then this formula can be used in H17, as in this example spreadsheet.

=(((H9-H7)*(4.18*(H3-H1)+O.23))/(H13*(H5-H3)))-((4.18*(H11-H9))/H13)

	A	B	C	D	E	F	G	H
1	Total weight of flask etc							0.80938
2								
3	Total weight of flask and 250ml of water							1.43946
4								
5	Total eight of flask + condense							1.50917
6								
7	Initial temperature of water in flask							22.5
8								
9	Final temperature of water and condense							77.5
10								
11	Average temperature delivered to sterilizer							144
12								
13	Latent heat of average temperature of steam delivered to sterilizer							2132.6
14								
15								
16								
17	Dryness fraction							0.955

Note! The formula has been modified from the default value of A = 0.24 kJ/K to 0.23 kJ/K to account for the use of a stainless steel flask and dip tubes instead of glass, as detailed in EN285.

Acceptance Criteria The test should be considered satisfactory if the following requirements are met:

The dryness value is equal to or greater than 0.95 and at least three tests are conducted.

The Superheat Test

Setting up

1. Assemble the apparatus as per Fig. 5

2. Isolate the steam supply and after checking that no residual pressure is present, insert a temperature sensor entry gland into the fitting on the steam pipe. The steam pipe may be hot and precautions should be taken against both burning and the presence of residual steam. The temperature probe should be at the geometric centre of the steam pipe. Insert the 0.8 mm pitot tube (= nominal 1 mm). Turn the steam supply back on, taking the necessary precautions against burning/scalding from the steam that will issue from the pitot tube.

Insert a temperature sensor through the entry gland of the expansion tube and position it so the sensing point of the thermocouple element is in the geometric centre of the expansion tube. Push the expansion tube onto the pitot tube taking the necessary precautions. This will require the tester to be in close proximity to the steam issuing from the pitot tube and extreme care is required to avoid scalding and/or burning. Gloves, overalls and eye protection must be worn.

Performing the Test

1. Ensure the sterilizer chamber is empty except for the usual chamber furniture. Select and start a porous load/equipment cycle.

2. From the measured temperatures, note the average temperature in the steam service pipe (for use in the dryness test) and in the expansion tube (Te) when the steam supply to the chamber first opens.

3. Calculate the superheat in °C from the following equation.

Superheat = Te – T0

Where T0 is the boiling point of water at local atmospheric pressure.

Acceptance Criteria

The test should be considered satisfactory if the superheat measured in the expansion tube does not exceed 25° C and the temperature measured in the steam pipe did not differ by more than 3°C from that measured in the steam pipe during the steam quality. **Note** Negative temperatures are normal.

Health and Safety

Care should always be taken when working on or near steam pipes due to the very high temperatures involved. Thermal gloves, overalls that cover arms and eye protection must be used.

While every effort has been made to provide protection from the extreme temperatures. care should be taken when testing with this equipment.

Do not plug or restrict the “Cooling Out‘ now as this may pressurize the heat exchanger. Which it has not been designed for.

Do not look into the condensate collection cylinder while the steam valve is open. as hot condense and/or steam could be ejected.

The submersible pump is electrically powered and care must be taken to prevent hazards arising from the use at electricity in a potentially wet environment.

Care and maintenance

No special care is required tor the steam test kit.

Should difficulty be found in obtaining a replacement or any other components. please contact your local Distributor in the first instance or Keith Shuttleworth & Associates Ltd for replacements.

Equipment specifications:

Non-condensable gas test kit	0-20% N/C per 100ml condensed steam
Dryness test	Full range
Superheat test	Full range
Steam supply tube	Max 10 barG Steam
8mm Coolant supply Tube	Max 3 barG at 20^{O}C
Condensing unit (Steam side)	Max 5 barG at 160^{O}C
Condensing unit (Water side)	Max 4 barG at 20^{O}C
Pitot Tubes	Max 6 barG at 165^{O}C

Appendix 1

Temp Deg C	Latent Heat	Temp Deg C	Latent Heat	Temp Deg C	Latent Heat	Temp Deg C	Latent Heat
120	2202.42	130	2174	140	2144.59	150	2114.06
120.2	2201.86	130.2	2173.43	140.2	2143.99	150.2	2113.44
120.4	2201.3	130.4	2172.85	140.4	2143.39	150.4	2112.82
120.6	2200.74	130.6	2172.27	140.6	2142.79	150.6	2112.19
120.8	2200.18	130.8	2171.69	140.8	2142.19	150.8	2111.57
121	2199.62	131	2171.11	141	2141.59	151	2110.95
121.2	2199.06	131.2	2170.53	141.2	2140.99	151.2	2110.32
121.4	2198.49	131.4	2169.95	141.4	2140.39	151.4	2109.69
121.6	2197.93	131.6	2169.37	141.6	2139.79	151.6	2109.07
121.8	2197.37	131.8	2168.79	141.8	2139.18	151.8	2108.44
122	2196.81	132	2168.21	142	2138.58	152	2107.81
122.2	2196.25	132.2	2167.62	142.2	2137.98	152.2	2107.19
122.4	2195.68	132.4	2167.04	142.4	2137.37	152.4	2106.56
122.6	2195.12	132.6	2166.46	142.6	2136.77	152.6	2105.93
122.8	2194.55	132.8	2165.87	142.8	2136.16	152.8	2105.3
123	2193.99	133	2165.29	143	2135.56	153	2104.67
123.2	2193.43	133.2	2164.71	143.2	2134.95	153.2	2104.04
123.4	2192.86	133.4	2164.12	143.4	2134.34	153.4	2103.41
123.6	2192.3	133.6	2163.54	143.6	2133.74	153.6	2102.78
123.8	2191.73	133.8	2162.95	143.8	2133.13	153.8	2102.15
124	2191.16	134	2162.37	144	2132.52	154	2101.51
124.2	2190.6	134.2	2161.78	144.2	2131.91	154.2	2100.88
124.4	2190.03	134.4	2161.19	144.4	2131.3	154.4	2100.25
124.6	2189.46	134.6	2160.61	144.6	2130.69	154.6	2099.61
124.8	2188.9	134.8	2160.02	144.8	2130.08	154.8	2098.98
125	2188.33	135	2159.43	145	2129.47	155	2098.34
125.2	2187.76	135.2	2158.84	145.2	2128.86	155.2	2097.71
125.4	2187.19	135.4	2158.25	145.4	2128.25	155.4	2097.07
125.6	2186.62	135.6	2157.66	145.6	2127.64	155.6	2096.44
125.8	2186.05	135.8	2157.07	145.8	2127.03	155.8	2095.8
126	2185.48	136	2156.48	146	2126.42	156	2095.16
126.2	2184.91	136.2	2155.89	146.2	2125.8	156.2	2094.52
126.4	2184.34	136.4	2155.3	146.4	2125.19	156.4	2093.89
126.6	2183.77	136.6	2154.71	146.6	2124.58	156.6	2093.25
126.8	2183.2	136.8	2154.12	146.8	2123.96	156.8	2092.61
127	2182.63	137	2153.53	147	2123.35	157	2091.97
127.2	2182.06	137.2	2152.93	147.2	2122.73	157.2	2091.33
127.4	2181.48	137.4	2152.34	147.4	2122.12	157.4	2090.68
127.6	2180.91	137.6	2151.75	147.6	2121.5	157.6	2090.04
127.8	2180.34	137.8	2151.15	147.8	2120.88	157.8	2089.4
128	2179.76	138	2150.56	148	2120.26	158	2088.76
128.2	2179.19	138.2	2149.96	148.2	2119.65	158.2	2088.11
128.4	2178.61	138.4	2149.37	148.4	2119.03	158.4	2087.47
128.6	2178.04	138.6	2148.77	148.6	2118.41	158.6	2086.83
128.8	2177.46	138.8	2148.18	148.8	2117.79	158.8	2086.18
129	2176.89	139	2147.58	149	2117.17	159	2085.54
129.2	2176.31	139.2	2146.98	149.2	2116.55	159.2	2084.89
129.4	2175.74	139.4	2146.39	149.4	2115.93	159.4	2084.24
129.6	2175.16	139.6	2145.79	149.6	2115.31	159.6	2083.6
129.8	2174.58	139.8	2145.19	149.8	2114.69	159.8	2082.95