1. Definition of Technology

Saturated steam to electricity conversion equipment is specifically designed to convert waste or excess saturated steam, from a specific process, into electrical power by means of a closed thermodynamic power cycle that does not involve the internal combustion of fuel.

2. Technology Description

Saturated steam to electricity conversion equipment covers products that are specifically designed to generate electrical power from waste or excess wet or saturated steam by reducing the steam pressure. The categories of product covered under the ETL scheme include:

1. Screw expanders - as wet steam passes through the product, it turns a screw rotor, which is connected to a generator. Energy is removed from the steam as the pressure reduces, which is converted into rotational shaft energy and then electricity.

2. Non-condensing or back pressure turbines - equipment which features rotary turbines where high pressure input steam is allowed to expand as it passes through the turbine. This releases energy and lowers the pressure of the steam at the outlet, without increasing the temperature.

Products should be sold as packaged units that can be fitted to industrial processes. Products that incorporate any form of combustion equipment, including boost burners, shall be excluded.

3. Eligibility Criteria

To be eligible, products shall:

- Utilise waste or excess steam source from a process (i.e. steam is not produced for the primary purpose of power generation).
- Use wet or saturated steam at the inlet (i.e. not superheated steam).
- Be designed to use water or steam as the thermal working fluid (i.e. product shall not use any thermal working fluid applicable to Organic Rankine Cycle).
- Not be part of a Good Quality CHP scheme, under CHPQA.
- Not exceed 700 kWe power output at standard conditions.
- Be designed to provide three-phase electricity output.
- Not incorporate any form of combustion equipment, including boost burners.
- Be designed and include fittings for permanent installation.
- Be CE marked.

Performance Criteria

Eligible products shall meet or exceed minimum overall efficiencies as set out in table 1. Minimum efficiencies shall be achieved across the specified range of inlet and outlet pressures. Eligible products shall also achieve a net electrical efficiency of at least 4.5%.
Table 1 - Overall efficiency thresholds for saturated steam to electricity conversion equipment

<table>
<thead>
<tr>
<th>No.</th>
<th>Product Category</th>
<th>Outlet Pressure Test Point (barA)</th>
<th>Minimum Overall Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Screw Expanders</td>
<td>2</td>
<td>&gt;= 84.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>N/A</td>
</tr>
<tr>
<td>2.</td>
<td>Non-condensing or back pressure turbines</td>
<td>2</td>
<td>&gt;= 72.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5</td>
<td>N/A</td>
</tr>
</tbody>
</table>

The Overall Efficiency is defined as:

\[
\text{Overall Efficiency (\%)} = \frac{\text{Net Electrical Output (kWe)}}{\text{Actual Enthalpy Drop (kJ/kg) \times Inlet Mass Flow Rate (kg/s)}}
\]

The Net Electrical Efficiency shall meet or exceed 4.5\% and is defined as follows:

\[
\text{Net Electrical Efficiency (\%)} = \frac{\text{Net Electrical Output (kWe)}}{\text{Inlet Enthalpy (kJ/kg) \times Inlet Mass Flow Rate (kg/s)}}
\]

Net electrical output is defined as the electrical output minus any electrical input into the product. Actual enthalpy drop is defined as the change in the inlet enthalpy of the steam entering the product minus the outlet enthalpy of the steam. The inlet mass flow rate is the flowrate of the steam as it enters the product.

Required Test Procedures

The required minimum performance shall be determined using Methods A or B, as set out in Tables A and B below.

**METHOD A – DIRECT MEASUREMENT**

Under this test method, product performance shall be demonstrated by calculating the overall efficiency from measurements of net electrical output, actual enthalpy drop and inlet mass flow rate. Overall efficiencies shall meet or exceed the threshold minimum efficiencies as set out in table 1.

Products can either be tested in an accredited laboratory, or performance may be determined from measurements made during field trials or acceptance tests, provided that the measurements have been made by, or witnessed by, an accredited laboratory or contractor that is accredited to make those measurements. The product’s overall
efficiency shall be calculated by an independent body that is competent to verify the measurement data.

The assessment shall be done in accordance with the procedures set out in:

- EN 306:1997 “Heat exchangers - Methods of measuring the parameters necessary for establishing the performance”; or
- BS EN 60953-2:1996 “Rules for steam turbine thermal acceptance tests, Part 2: Method B: Wide range of accuracy for various types and sizes of turbines”

The assessment of electrical output and electrical input shall be done in accordance with the relevant procedures set out in:

- BS ISO 8528-6:2005 “Reciprocating internal combustion engine driven alternating current generating sets - Test methods”.

METHOD B – VALIDATED DESIGN CALCULATIONS

Under this test method, product performance shall be demonstrated by calculating overall efficiency and net electrical efficiency from design calculations. The accuracy of these calculations shall be verified by an independent accredited laboratory.

The product shall not exceed the threshold electrical power output of 700 kWe at standard conditions.

The test report shall include (or be accompanied by):

a) Manufacturer’s design data for the product
b) Details of the methodology (including any standards used) and calculations verified by the independent accredited laboratory, used to determine product performance
c) A copy of the published performance data for the product

4. Scope of Claim

Expenditure on the provision of plant and machinery can include not only the actual costs of buying the equipment, but other direct costs such as the transport of the equipment to site, and the direct costs of installation. Clarity on the eligibility of direct costs is available from HMRC.