LPCB®

Loss Prevention Standard

LPS 1131: Issue 1.2

Requirements and testing methods for pumps for automatic sprinkler installation pump sets

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PARTICIPATING ORGANISATIONS

This standard was prepared by Technical Panel C of the Loss Prevention Certification Board. The following organisations participated:

Association of British Insurers	ABI
British Automatic Sprinkler Association	BASA
Confederation of British Industry	CBI
Local Government Association	LGA
Loss Prevention Council	LPC
Risk Engineers Data Exchange Group	REDEG

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The issue number will be given in decimal format with the integer part giving the issue number and the fractional part giving the number of amendments (e.g. Issue 3.2 indicates that the document is at Issue 3 with 2 amendments).

USERS OF LOSS PREVENTION STANDARDS SHOULD ENSURE THAT THEY POSSESS THE LATEST ISSUE AND ALL AMENDMENTS.

FOREWORD

This standard identifies The Loss Prevention Certification Board (LPCB) evaluation and testing practices for the certification and listing of suitable products. Certification is based on the following criteria:

i. Satisfactory product performance and construction, in accordance with the requirements of the LPCB and the manufacturer's specifications.

ii. LPCB Certification of the manufacturer's quality management systems in accordance with ISO 9001, Quality management systems. Requirements.

iii. Satisfactory product service experience.

Products that conform to the published requirements of the LPCB, but the construction of which is considered improper, may be refused certification and listing.

NOTES

Compliance with this LPS does not of itself confer immunity from legal obligations. Users of LPSs should ensure that they possess the latest issue and all amendments.

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1. SCOPE

This Standard defines the LPCB's certification requirements for centrifugal pumps used in pump sets in automatic sprinkler installations conforming to the LPC *Rules for Automatic Sprinkler Installations*.

The types of centrifugal pump covered by this specification include single and multistage, horizontal and vertical, split case or end suction types. Close-coupled pumps are also included.

This specification does not include requirements for the pump set driver or controller.

2. DEFINITIONS

For the purposes of this Standard the following definitions apply.

2.1 Total Head (Absolute)

The absolute total head at any section of a pump is given by:

Static head + atmospheric pressure head
+ dynamic pressure head
+ difference in level between reference plane and the section being considered.

2.2 Pump Total Head (Generated Head)

The difference between the pump outlet total head and the pump inlet total head.

2.3 Closed Valve Condition

The condition under which there is zero flow through the installation.

2.4 Maximum Working Pressure

The rating on the pump nameplate, which meets the hydrostatic pressure test requirements of 6.1.

2.5 Rated Speed

The speed of rotation at which the pump is certificated.

2.6 Pump Power Input

The power required to drive the pump at rated speed and a given total head and flow rate.

2.7 Pump Efficiency

The ratio of pump power output to pump power input.

2.8 Net Positive Suction Head (NPSH)

The total head (absolute) at the pump inlet centreline minus the vapour pressure head.

2.9 Required NPSH at a given flow rate and speed of rotation is the minimum NPSH at the pump inlet centreline necessary to maintain a stable flow rate and suppress cavitation through the pump.

2.10 Available NPSH is the NPSH at the pump inlet.

3. DESIGN

3.1 General

3.1.1 **Pump Total (Generated) Head -v- Flow Rate Curve**

The curve of pump total head -v- flow rate shall be stable, i.e. all tangents to the curve shall have zero or negative slope. The curve may be corrected for pump induced pre-swirl using the method described in BS 5316: Part 1: 1976 (ISO 2548), Annex A.

The pump total head at the rated speed shall not exceed 12 bar in the closed valve condition.

Note: Applications for approval of pumps with higher pressures will be accepted, e.g. for high rise sprinkler systems and special applications.

3.1.2 **Operating Range**

Pumps will only be approved for use at flow rates at which the NPSH required is below 5.38m. This flow rate shall be clearly marked on the performance curves for the range of impeller diameters or speeds.

3.1.3 **Closed Valve Conditions**

A minimum bypass flow rate shall be specified, to minimise the possibility of pump failure in the closed valve condition.

3.2 Speed of Rotation

3.2.1 **General**

The pump shall be capable of meeting all the conditions of this standard at the rated speed.

3.2.2 **Balance and Vibration**

The rotating parts of the pump shall be balanced in accordance with grade G 6.3 of BS 6861 : Part 1 : 1987 (ISO 1940/1), Clause 6. There shall be no undue vibration.

3.3 Maximum Working Pressure of Pump

The maximum working pressure of the pump shall be that which meets the hydrostatic pressure test requirements of 6.1.

3.4 Mechanical Features

3.4.1 **Dismantling**

The pump shall be designed to permit dismantling, without disturbing the system pipework.

3.4.2 **Casing Gaskets**

Casing gaskets shall satisfy the operating conditions and hydrostatic test conditions at ambient temperature. Compliance shall be demonstrated by the test in Clause 6.1.1.

3.4.3 **External Bolting**

Bolts or studs that connect pressure containing parts shall be selected to be adequate for the pump pressures and for normal tightening procedures. Compliance shall be demonstrated by the test in Clause 6.1.2.

3.5 Branches and Miscellaneous Connections

3.5.1 **Type and Size**

The type and size of all connections to the pump shall be specified by the manufacturer, and shall be of adequate material and thickness for the intended duty.

3.5.2 **Connections**

Connections for vents, pressure-gauges and drains shall be fitted with removable closures to contain maximum working pressure. Closures shall satisfy the hydrostatic pressure test described in Clause 6.1.

3.5.3 **Branch Flanges**

The branch flanges shall conform to BS 4504 : Section 3.2 : 1989 - PN 16 or BS 1560-3.2: 1989, Class 150.

3.5.4 **Closed Head Relief Valve**

The closed head relief valve shall be regarded as part of the pump and it should be of the non-adjustable differential pressure type.

The valve may have a facility for adjustment for setting up on site, but shall be tamper-proof after setting.

3.6 Impellers

Impellers shall be positively and securely attached to the pump shaft by recognised engineering methods.

3.7 Casing Wear Rings

Where casing wear rings are fitted, they shall be prevented from rotating.

3.8 Running Clearance.

When establishing running clearance between stationary and moving parts, consideration shall be given to operating conditions and properties of the material used (such as hardness and gall resistance) for these parts. Clearances shall be sized to prevent contact, and material combinations selected to eliminate seizure and minimize erosion, taking account of the pump application which involves long periods in the stationary condition.

3.9 Shafts and Shaft Sleeves

3.9.1 **General**

Shafts shall be of ample size and stiffness to:

a) transmit the prime mover rated power;
b) minimize unsatisfactory packing or seal performance;
c) minimize wear and the risk of seizure;
d) take due consideration of method of starting and inertia loading involved.

3.9.2 **Axial Movement**

Axial movement of the rotor permitted by the bearings shall be limited by design to not adversely affect the performance of the mechanical seal, where fitted.

3.9.3 **Shaft Stresses**

Shaft stresses shall not exceed:

30% Yield stress for torsional and shear stresses, and
18% Ultimate tensile strength for principal stresses

in respect of the following conditions:

a) Torsional shear stress at the coupling end of the shaft at maximum power or impeller attachment whichever is the greater (ref. Appendix A).
b) Principal direct stress and maximum shear stress at impeller attachment under closed valve conditions (ref. Appendix A).

For close coupled pumps, removable shaft extensions shall be securely fitted to the motor shaft to accommodate the most arduous combination of torsional and axial forces.

3.10 Bearings

3.10.1 **Rolling Bearings**

Pumps shall be fitted with rolling bearings where there is no reliance on associated driver bearings.

For close coupled pumps the motor bearings shall also conform to the following requirement.

Rolling bearings shall be selected in accordance with BS 5645 : 1987 (ISO 76) and BS 5512 : 1991 (ISO 281). The minimum calculated life rating (L_{10}) shall not be less than 5000 hours at closed valve conditions at maximum impeller diameter and rated speed.

3.10.2 **Lubrication**

Information on the type of lubrication to be used and the frequency of application shall be stated in the operation instructions.

3.10.3 **Bearing Housing Design**

The bearing housing shall be designed to minimise the ingress of contaminants and the escape of the lubricant under normal operating conditions.

3.11 Shaft Sealing

3.11.1 **General**

The pump may use mechanical seals or soft packaging.

3.11.2 **Stuffing Box**

Ample space shall be provided for repacking without removing or dismantling any part other than gland components or guards.

3.11.3 **Mechanical Seals**

The mechanical seal shall be suitable to withstand the given operating conditions.

Material for the seal components shall be chosen to withstand corrosion, erosion, temperature and mechanical stress etc. For mechanical seals metallic parts wetted by the pumped liquid shall have at least the same material quality as the pump casing as far as mechanical properties and corrosion resistance are concerned.

A mechanical seal shall not be subjected to a hydrostatic pressure exceeding the seal pressure limit.

3.12 Orifice Plates

3.12.1 **General**

Orifice plates shall only be fitted in pump outlets of 50mm nominal bore or greater.

3.12.2 **Requirements**

Where fitted, orifice plates shall:

a) have an orifice diameter not less than one-half of the internal diameter of the pump outlet into which it is fitted;

b) be of brass with a plain central hole without burrs, and of a thickness complying with Table 1;

c) be integral with or securely attached to the pump outlet; and

d) have an identification tag, projecting beyond any flanges between which it is clamped or secured, on which is clearly stamped the nominal pump outlet diameter and the orifice k factor (see 3.12.3).

Table 1. Orifice plate thickness according to pump outlet nominal bore

Pump outlet nominal bore (mm)	Orifice plate minimum thickness (mm)
≥50 to ≤80	3
≥80 to ≤150	6
≥150 to ≤200	9

3.12.3 **Orifice plate k factor**

The k factor of a non-integral orifice plate shall be calculated from:

$$k = \frac{Q}{\sqrt{p}}$$

where Q = flow rate (*l*/min)
p = pressure drop across the orifice plate with flow Q(bar)

4. MARKING

4.1 Nameplate

The pump shall have securely fitted to it a nameplate which is durable, non-combustible, legible and indelible.

The nameplate shall contain the following information:

a) Supplier's name or trademark.
b) Supplier's address.
c) Model designation.
d) Serial number.
e) Year of manufacture.
f) LPCB Approval Mark and Reference No.
g) Rated flow (L/min).

h) Rated speed. (revs/min).
i) Rated total head (generated head)(bar).
j) Fitted impeller diameter (mm).
k) Maximum working pressure (bar).
l) Maximum absorbed power (kW) at the rated speed and flow conditions.
m) Where an orifice plate is required but is not integral with the pump outlet, a statement that the performance is that of the pump and orifice plate combination and the k factor of the orifice plate.

4.2 Direction of Rotation

The direction of rotation shall be indicated by a prominently located and securely attached durable rotation arrow.

4.3 Materials

Pump shafts where in contact with water shall be made of corrosion resistant materials. Protective sleeves for shafts, and impeller fastenings shall be made from corrosion resistant material

5. DOCUMENTATION

Each pump shall be supplied with a characteristic curve sheet which includes the following particulars:

a) Pump and driver serial numbers.
b) Test date.
c) Place of test.
d) Pump total head (generated head) curve (bar).
e) NPSH required curve (m).
f) Power input curve (kw).
g) Rate of flow (L/min) at NPSH (required) = 5.38m.
h) Rated speed (revs/min).
i) Impeller diameter (mm).
j) Model designation.
k) Minimum bypass flow rate (L/min).
l) Nominal bore of inlet flange (mm).
m) Nominal bore of outlet flange (mm).
n) Orifice identification.
o) Witnessed by signature.

6. TESTS

6.1 Hydrostatic Pressure Test

6.1.1 The pump shall be hydrostatically tested at 20°C ± 5°C to 1.5 times the maximum working pressure for 10 minutes. There shall be no visible leakage from the pump.

6.1.2 The pump shall be hydrostatically tested at 20°C ± 5°C to 2 times the maximum working pressure for 10 minutes. There shall be no cracking or rupture of the casing.

6.2 Closed Valve Test

The pump with maximum impeller size shall be run in the closed valve condition, with specified minimum bypass flow. The bypass flow rate and pump temperature shall be recorded.

The pump shall be run at the maximum rated speed for two hours.

The pump total head curve (6.3) shall then be verified.

After the test the wear surface and impeller shall be examined and their condition recorded. There shall be no significant wear.

6.3 Performance Tests

6.3.1 Performance tests shall be carried out in accordance with BS 5316 : Part 1 : 1976 (ISO 2548).

A pump model with a range of duties shall be tested with maximum and minimum impeller diameters and also with an intermediate impeller diameter where deemed necessary

If the range of duties is achieved using orifice plates at the pump outlet, the pump will be tested using maximum, minimum and an intermediate orifice plate diameters.

The approval test speed shall be within $\pm$ 4% of the pump rated speed. All test data shall be corrected to rated speed to determine approval performance characteristics.

6.3.2 The following performance characteristics of the pump shall be verified at the rated speed, over a range of flow rates:

6.3.2.1 **Pump Total Head**

The Pump Total Head shall be verified after the closed valve test (6.2).

The specified minimum bypass flow rate (determined in 6.2) shall be run to waste when the curve is verified.

The verified curve represents individual duty points that may be guaranteed for the pump.

Where a guaranteed duty point is verified in accordance with clause 9.4 of BS 5316 : Part 1 : 1976, the guaranteed duty point shall be within the test curve (there shall be no negative value of the guarantee point).

6.3.2.2 **Required Net Positive Suction Head Curve**

The NPSH required curve shall be determined using clean cold water as specified in BS 5316: Part 1: 1976 (ISO 2548), Clauses 4.2.3 and 8.1.

The flow rate at which the NPSH required is 5.38m shall be clearly marked on the performance curves for the range of impeller diameters and speeds tested.

6.3.2.3 **Pump Power Input Curve**

The maximum pump power input shall be verified to a maximum flow rate corresponding with the following requirements:

a) For pumps with an ever increasing power input, to an NPSH required at the pump suction flange, of 16 metres: An NPSH of 16 metres shall be available.

b) For pumps with a detectable peak power value (at an NPSH required of less than 16 metres), until a peak is determined: It shall be demonstrated that the peak is occurring by design and not cavitation.

APPENDIX A : STRESS CALCULATIONS

Reference Clause 3.9.3

A.1 Torsional shear stress at the coupling end of the shaft and at the impeller attachment at maximum power is calculated from the following.

$$S_{tc} \text{ or } S_{tr} \ (N/m^2) = \frac{16\ T_m}{\pi\ (D_c)^3}$$

$$\text{where } T_m \ (N.mm) = \frac{9.549 \times 10^6\ P_m}{\text{rpm}}$$

A.2 Maximum principal direct stress and maximum shear stress at impeller attachment under closed valve conditions are calculated from the following:

$$S_{pr} \ (MN/m^2) = \frac{16}{\pi\ (D_r)^3}\ [M + \sqrt{(M^2 + (T_{cv})^2)}\ ]$$

$$\text{and } S_{sr} \ (MN/m^2) = \frac{16}{\pi\ (D_r)^3}\ \sqrt{(M^2 + (T_{cv})^2)}$$

where $M = M_{sc}$ or M_{es}

Nomenclature and Units

S_{tc} (MN/m^2) - Torsional stress at coupling diameter

S_{tr} (MN/m^2) - Torsional stress at diameter under impeller

S_{sr} (MN/m^2) - Maximum shear stress at diameter under impeller at closed-valve conditions

S_{pr} (MN/m^2) - Maximum principal stress at diameter under impeller at closed-valve conditions

D_c (mm)-	-	Shaft diameter at coupling
D_r (mm)-	-	Shaft diameter under impeller
P_m (kW)-	-	Maximum power
T_m (N.mm)	-	Torque at maximum power conditions
T_{cv} (N.mm)	-	Torque at closed-Valve conditions
rpm	-	Rotational speed in revolutions per minute
M_{sc} (MNm)	-	Bending moment : Split-case
M_{es} (MNm)	-	Bending moment : End-suction

APPENDIX B : NPSH CALCULATIONS

(In preparation)

PUBLICATIONS REFERRED TO

Reference	Title
ISO 9001	Quality management systems. Requirements:
BS 5306: 2: 1990 and LPC Technical Bulletins	LPC Rules for Automatic Sprinkler Installations
BS 5316 : Part 1 : 1976 (ISO 2548)	Specification for acceptance tests for centrifugal, mixed flow and axial pumps Class C tests.
BS 6861 : Part 1 : 1987 (ISO 1940/1)	Method for determination of permissible residual imbalance.
BS 1560-3.2 : 1989	Circular flanges for pipes, valves and fittings (Class designated) Specification for cast iron flanges.
BS 4504 : Section 3.2 : 1989	Circular flanges for pipes, valves and fittings (PN designated) Specification for cast iron flanges.
BS 5645 : 1987 (ISO 76)	Specification for static load ratings for rolling bearings.
BS 5512 : 1991 (ISO 281)	Method of calculating dynamic load ratings and rating life of rolling bearings.

Amendments Issued Since Publication

DOCUMENT NO.	AMENDMENT DETAILS	SIGNATURE	DATE
LPS 1131-1	Copyright and address change	CJA	24/10/01
LPS 1131-1	Further copyright changes	CJA	29/07/02
LPS 1131-1.2	1. New front cover 2. Title added to header 3. Contents page moved to Page 1. 4. 'Revision of Loss Prevention Standards' added on Page 2 5. Notes added on Page 3 6. Updated references to ISO 9001 'Quality management systems, Requirements' in the 'Foreword' and in 'Publications Referred To' 7. All references to ISO 9002 deleted (Standard withdrawn and replaced by ISO 9001) 8. Repagination 9. Update of copyright information	DC	Jan. 2014