

Application Guidance Notes: Technical Information from Cummins Generator Technologies

AGN 066 – Alternator IP Protection

IP CODES

British Standard (BS) EN 60529:1992 + A2:2013 describes the system for classifying the degrees of protection provided by the enclosures of electrical equipment. The majority of AvK and STAMFORD alternators are air-cooled, with the air being drawn through the alternator by an internal fan, which is fitted to the Drive End (DE) of the alternator shaft. Thus, the cooling airflow enters the alternator via the Non-Drive End (NDE), with the hot air being expelled at the DE.

Each of the openings associated with the cooling-air path must be fitted with a screen and, on occasion, an additional louver to comply with the relevant EU Directives for ac generators (alternators); primarily 2006/42/EC Machinery Directive. The chosen design of screen and louver will provide different levels of protection against the ingress of solid objects, plus the harmful ingress of liquids.

The degree of enclosure protection provided is indicated by the International Protection or 'IP' Code where the code typically includes two numbers. The first number is associated with the degree protection for persons, or limiting the size of solid objects that can enter the machine. The second number is associated with liquid ingress protection, water being the most likely liquid that the alternator may be exposed to.

A typical alternator intended for use in an industrial application has an IP code number of 23 (IP 23). The '2' indicates that an object bigger than 12.5mm diameter, for example a finger, cannot enter the alternator and touch anything either moving or electrically live. The '3' indicates that the alternator's ventilation openings are designed to provide protection from falling liquids,

for example rain water, which may be blown by the wind towards the alternator at some 60° from the vertical. The following tables provide definition of the numbers and additional letters that make up the IP code:

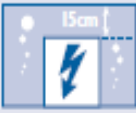
FIRST NUMERAL

Protection against ingress of solid foreign objects

Meaning protection of persons against access to hazardous parts with:

IP	Requirements	Example	
0	no protection		no protection provided
1	full penetration of 50.0mm diameter sphere not allowed and shall have adequate clearance from hazardous parts. Contact with hazardous parts not permitted		back of hand
2	full penetration of 12.5mm diameter sphere not allowed. The jointed test finger shall have adequate clearance from hazardous parts		finger
3	the access probe of 2.5mm diameter shall not penetrate		tool
4	the access probe of 1.0mm diameter shall not penetrate		wire
5	limited ingress of dust permitted (no harmful deposit, refer to standard)		wire
6	totally protected against ingress of dust		wire

SECOND NUMERAL

Protection against harmful ingress of water			Meaning for protection from ingress of water:
IP	Requirements	Example	
0	no protection		no protection provided
1	protected against vertically falling drops of water.		vertically dripping
2	protected against vertically falling drops of water with enclosure tilted 15° from the vertical.		Enclosure tilted 15° from the vertical
3	protected against sprays to 60° from the vertical.		limited spraying
4	protected against water splashed from all directions.		splashing from all directions
5	protected against low pressure jets of water from all directions.		hosing jets from all directions
6	protected against strong jets of water		strong hosing jets from all directions
7	protected against the effects of immersion between 15.0 cm and 1.0 m		temporary immersion
8	protected against longer periods of immersion under pressure		immersion

ADDITIONAL LETTER

(Optional)

Meaning protection of persons against access to hazardous parts with:

A

For use with first numerals 0

penetration of 50.0mm diameter sphere up to guard face must not contact hazardous parts.



B

For use with first numerals 0 & 1

test finger penetration to a maximum of 80.0mm must not contact hazardous parts



C

for use with first numerals 0, 1 & 2

wire of 2.5mm diameter x 100.0mm long must not contact hazardous parts when spherical stop face is partially entered



D

For use with first numerals 0, 1, 2 & 3

wire of 1.0mm diameter x 100.0mm long must not contact hazardous parts when spherical stop face is partially entered



Limited penetration allowed with X1, X2, X3, X4, X5 and all four additional letters. Refer to standard.

An additional letter may be used to further define the protection of persons against access to hazardous parts.

IP RATINGS ON STAMFORD ALTERNATORS

All STAMFORD alternators have a standard build with enclosure protection rated at IP23. An optional upgrade package is available, that must be fitted during manufacture, to increase the enclosure protection rating to IP44 on the S4/S5 (single bearing only), HC6 (S6), and P7 (S7) alternators. The IP44 package is not, however; available on the P734G, P734H and S7L1-J alternators. It is to be noted that the auxiliary terminal box for certain Automatic Voltage Regulators (AVR) may not be rated to IP44.

The expectations of the IP44 level of protection are:-

- **Protection against solid objects (Mechanical protection):** that a straight 1mm diameter steel rod cannot be pushed into the machine and touch any moving or live part.
- **Protection against the ingress of liquids (Water ingress):** that water falling as a spray, or water splashing against the side of the machine, shall have no harmful effect.

The mechanical protection is achieved by blanking off the standard air inlet aperture. A tortuous path moisture filter constructed from aluminium extrusions is fitted at the air inlet, which is now on the side of the alternator, below the terminal box. Filters are fitted on both sides of the HC6 (S6) and just one side of the S4, S5, P7 (S7), left or right. A fine stainless steel woven mesh is fitted to the air outlet regions on the S4, S5, HC6 (S6), and P7 (S7).

The problems associated with water ingress are resolved at the air outlet by use of 'Marine' style louvres – the louvres that are designed to be fitted to all Marine alternators. It should be noted that this only offers effective protection when the machine is running. However, drain holes are engineered into the drive-end bracket to allow any water that has entered, to drain away. Plant maintenance should always involve checking that these holes are clear.

Moisture Filters are fitted to the S4, S5, HC6 (S6), or P7 (S7) alternators to achieve the IP44 package. The moisture filter used in a Premaberg type and is made to a specific size to fit the S4, S5, HC6 (S6), or P7 (S7) frame size air inlet aperture. The Premaberg filter is designed for removing airborne water droplets from the cooling air stream.

This type of filter is designed to function by a fundamental principle known as a 'tortuous path'. Here the cooling air stream is passed through a filter system providing large area therefore, relatively low air speed. The cooling air is then made to turn through many 90° changes of direction around multiple vertical aluminium vanes. At each directional change the heavier than air water droplet collides with a vane and is then held against a barb formed as part of the extruded aluminium vane. The water droplets then drain under gravity to a designed drain point and drip to atmosphere away from the cooling air flow path. The clearance between the vanes

is typically 10mm, which is ideal for the filtration of water droplets, but renders these filters virtually useless for dry dust filtration.

Alternator De-rate

When the IP44 package is fitted on a S4, S5, HC6 (S6), or P7 (S7) alternator, the output kVA rating must be de-rated by 10%, to compensate for the reduction in air flow through the alternator.

P80 Alternators

The standard build enclosure protection is rated at IP23. The terminal box on Low Voltage (LV) P80 alternators is also IP23. The terminal box on Medium Voltage (MV) and High Voltage (HV) P80 alternators is IP23 as standard with the option of IP44.

S9 Alternators

The standard build enclosure protection is rated at IP23. The terminal box on standard S9 alternators (with flat panel terminal box) is IP54.

IP RATINGS ON AvK ALTERNATORS

All AvK alternators have a standard build with enclosure protection rated at IP23. There are a number of options available to increase enclosure protection to a higher IP Rating:

- IP23 SOLAS (safety of life at sea) for Marine Alternators
- IP44R (open top inlet and outlet for later fitting of ducting)
- IP44 (equipped with Premaberg filter)
- IP44 (equipped with Cooler)
- IP54 or IP55 (equipped with Cooler)

A variation of options are available to satisfy detailed customer requirements, up to achieving a 'Totally Enclosed' electrical machine with IP55. IP54 and IP55 enclosures require heat exchangers and these are optional on IP44.

The heat exchangers are mounted onto the alternator to allow the internal region encasing the electrical wound assemblies to be sealed off from local environmental related air borne contamination. The heat exchanges can be based on water cooling identified by the term Cooling Air Cooling Water (CACW), or air cooling identified by Cooling Air Cooling Air (CACA).

For IP54 and IP55 enclosure protection, the design will be similar to the IP44 design equipped with cooler, but the type of sealing will change accordingly.

The standard IP23 AvK alternator will have a terminal box rated at IP54. The terminal box will match the alternator IP Rating on IP54 and IP55 alternators. The terminal box may be repositioned to the side of the alternator. This must be done when a heat exchanger is fitted.

Alternator Rating

The required IP rating will be designed into the alternator during the order process. At the same time, the alternator's rating will be known.

OPTIONAL UPGRADES

There are operational conditions where internal condensation can occur; furthermore, situations may arise where water is forced through the ventilation openings into the alternator. Such eventualities need to be risk assessed and corresponding avoiding steps should be taken by the Generating Set manufacturer, along with the installation team at the point of Generating Set installation. The risk of unwanted water puddling inside the alternator is addressed by Cummins Generator Technologies, with the incorporation of appropriately-sized drain holes strategically located within each end-bracket and the frame.

Anti-condensation heaters:

Anti-condensation heaters are recommended as a means of dealing with site conditions where excessively-high levels of Relative Humidity (RH%) could result in an environment detrimental to maintaining a robust electrical insulation system for the wound assemblies within an alternator. These heaters are specifically designed to operate at a 'black heat' yet provide sufficient heat to ensure adequate control by eliminating condensation within the AvK or STAMFORD alternator housing. But not when a Generating Set installation is 'open to the elements'.

Controlling the ambient temperature and RH% within a Generating Set enclosure must be assigned to an appropriately selected and positioned Space Heater, where the associated power level will be some 2kW of blown heat.

Dry Dust Filters:

An air-inlet filtration package for dry, dusty conditions is also available for AvK and STAMFORD alternators. The package is fitted to the NDE region and includes washable filter elements able to trap and hold particles down to 20 microns. However, a de-rate of 5% must be applied to the alternator's output kVA, to compensate for a dirty filter restricting the airflow through the alternator. This filter arrangement does not change the existing IP23 rating. Note: washable dust air-inlet filters have a poor capability to remove airborne water droplets as they soon saturate and then drip water into the alternator. For further information, refer to AGN 065.

Any alternator specified to have air-inlet filters should also have stator winding temperature sensors to prevent excessive (i.e. life-shortening) operating temperatures. These sensors should be included within the Generating Set control system to prompt filter maintenance, which should be specifically included in the Generating Set's maintenance regime.

SUMMARY

IP Codes indicate the level of environmental and mechanical protection available on an individual alternator and Generating Set. However, additional protection may be required on a Generating Set depending on the local operating conditions. A full site-survey/risk analysis prior to installation will determine whether additional environmental protection is necessary above-and-beyond the standard protection. This AGN includes a couple of optional additional protection systems to combat specific local conditions, along with advice on their use. Their use should always be discussed with Application Engineering prior to the Generating Set installation. Further guidance is available in AGN 072 – Environmental Conditions.