What is S1 Duty Cycle ?

The European practice (standards) differentiates 10 different basic duty cycles. It was developed from the electric motor “point of view” it is an IEC standard term.

Neugart is referring to S1 in the catalog to clearly define that the gearbox rating is for Continuous Duty

1.2 Duty and Rating

The CEI. IEC 34- 1 is an internal standard for rotating machines and should be discussed here. The duties and ratings are especially important.
Duty types Duty. The duty may be described by one of the duty types defined later or by the specification of another duty by the purchaser.
Declaration of duty. It is the responsibility of the purchaser to declare the duty as accurately as possible.
In certain cases where the load does not vary or where it varies in a known manner, the duty may be declared numerically or with the aid of a time sequence graph of the variable quantities.
If the time sequence is indeterminate a fictitious time sequence (duty types S2 to S8) not less onerous than the true one shall be selected, or the duty type S9 shall be applied.
The duty is not stated, duty type S1 (continuous running duty) applies.
Rating. The manufacturer assigns the rating by selection of one of the classes of rating defined. The class of rating selected shall normally be maximum continuous rating based on duty type S1 (continuous running duty), rating with discrete constant loads rating based on duty type S10 (duty with discrete constant loads) or short-time rating based on duty type S2 (short-time duty).
If this is not possible, a periodic duty type rating based on one of the duty types S3 to S8 (periodic duty) or the non periodic duty type rating based on the duty type S9 (non-periodic duty) shall be selected.
Selection of a class of rating. Where a machine is manufactured for general purposes, it shall have maximum continuous rating and be capable of performing duty type S1.
If the purchaser has not specified the duty, duty type S1 applies and the class of rating assigned shall be maximum continuous rating.
When a machine is intended to have a short-time rating, the rating shall be based on duty type S2 as defined and as designated.
When a machine is indented to supply varying loads or loads including a period of no-load or periods where the machine will be in a state of rest and de-energized, the class of rating shall be a periodic duty type rating based on a duty type selected from duty types S3 to S8.
When a machine is indented non-periodically to supply variable loads at variable speeds, including overloads, the non-periodic duty type rating shall be based on duty type S9.
When a machine is indented to supply discrete constant loads including periods of overload or periods of no-load, or periods where the machine will be in a state of rest and de-energized, the class of rating shall be a rating with discrete constant loads based on duty type S10.
In some cases, a test at the actual or estimated duty may be arranged by agreement between manufacturer and purchaser but such a procedure is not generally practical.

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In the determination of the rating:

- for duty types S1 to S8, the specified value(s) of the constant load(s) is taken to be the rated output and is expressed in Watts for motors and Volt-Amperes for generators.

Duty types. Generally speaking, the following definitions are valid:

Definitions: operation at constant load: operating time t_b;

N(IEC34-1); time constant: T_b

Starting duration: t_a; D (IEC 34-1))

pause, at rest and de-energized: t_p;

R (IEC 34-1), time constant T_p

operation on no load: V (IEC 34-1)

electric braking duration: t_{Br}; F (IEC 34-1)

(a) Continuous running duty - Duty type S1. Operation at constant load of sufficient duration for thermal equilibrium to be reached (see Fig. 1.1)

$$\frac{t_b}{T_b} > 3 \;;\; \frac{t_p}{T_p} > 3.$$

The factor 3 results from thermal dynamic response with e^{-1/T_ϑ}.
the final stationary value (95%) is reached with $t \approx 3T_\vartheta$

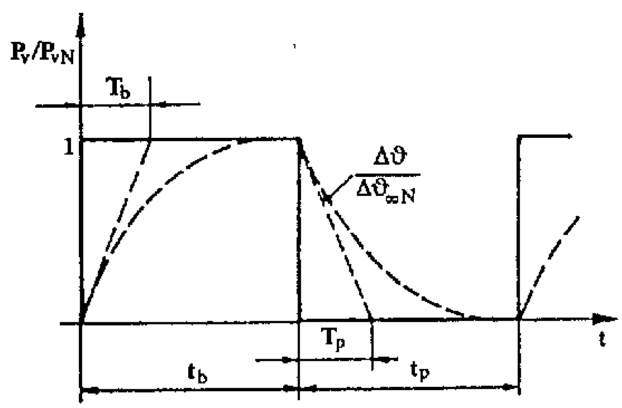

Fig. 1.1. Continuous running duty (S1)

$$\text{Thermal load allowed: } \frac{\Delta\vartheta_\infty}{\Delta\vartheta_{\infty N}} \le 1; \quad \frac{P_V}{P_{VN}} \Rightarrow 1;$$

(b) Short-time duty - Duty type S2. Operation at constant load during a given time, less than that required to reach thermal equilibrium, followed by a rest and de-energized period of sufficient duration to reestablish machine temperatures within 2 K of the coolant (see Fig. 1.2).

$$\frac{t_b}{T_b} < 3;\ \frac{t_p}{T_p} > 3.$$

Characteristic: the final stationary operation temperature is not reached; but during rest period the coolant temperature is always reached ($\Delta\vartheta = 0$).

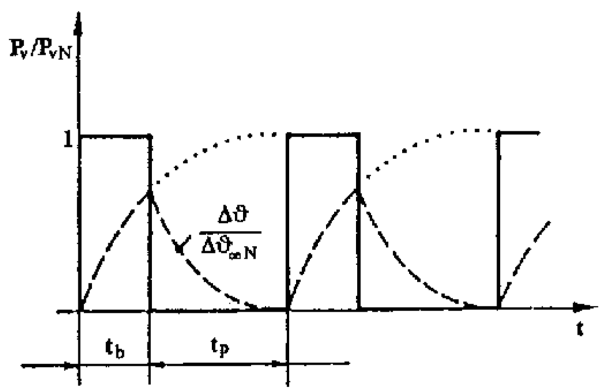

Fig. 1.2. Short time duty (S2)

$$\frac{\Delta\vartheta_{\infty}}{\Delta\vartheta_{\infty N}} = \frac{1}{1-e^{-t_b/T_b}};$$ Overloading of the machine in this particular type of operation

⇓

$$\frac{\Delta\vartheta_{\infty}}{\Delta\vartheta_{\infty N}} = \frac{P_V}{P_{VN}} \geq 1 \rightarrow i_{adm} = \sqrt{\frac{1+\nu}{1-e^{-t_b/T_b}} - \nu}\ .$$

(c) Intermittent periodic duty - Duty type S3. A sequence of identical duty cycles, each including a period of operation at constant load and a rest and de-energized period (see Fig. 1.3). In this duty, the cycle is such that the starting current does not significantly affect the temperature rise. Note - Periodic duty implies that thermal equilibrium is not reached during the time on load.

$$\frac{t_b}{T_b} < 3 \quad \frac{t_p}{T_p} < 3.$$

Characteristic: the temperature "oscillates" between $\Delta\vartheta_1$ and $\Delta\vartheta_2$ during operation and rest, there is a transient response additionally.

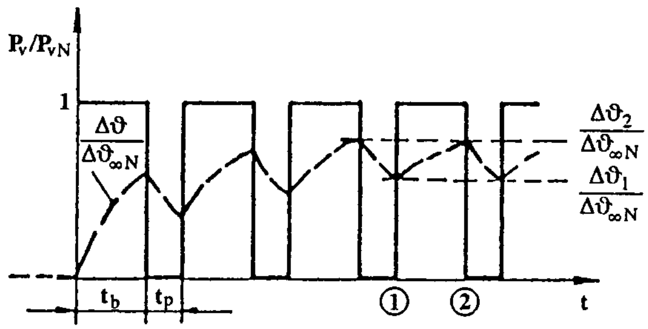

Fig. 1.3. Intermittent periodic duty (S3)

Cycle period $t_s = t_b + t_p$.

Normalization $\tau_b = \frac{t_b}{T_b}$; $\tau_p = \frac{t_p}{T_p}$, $\varepsilon = \tau_b / (\tau_b + \tau_p)$.

Resulting in:

$$\frac{\Delta\vartheta_2}{\Delta\vartheta_\infty} = \frac{1 - e^{-\tau_b}}{1 - e^{-(\tau_b + \tau_p)}} \le 1 .$$

For periodic operation:
$$\begin{cases} \dfrac{\Delta\vartheta_2}{\Delta\vartheta_\infty} = \dfrac{1 - e^{-t_b/T_b}}{1 - e^{-(t_b/T_b + t_p/T_p)}} \le 1 \\ \Delta\vartheta_1 = \Delta\vartheta_2 \, e^{-t_p/T_p} \end{cases}$$

thermal load allowed (being $i = I/I_N$):

$$\frac{\Delta\vartheta_\infty}{\Delta\vartheta_{\infty N}} = \frac{1 - e^{-(\tau_b + \tau_p)}}{1 - e^{-\tau_b}} = \frac{P_V}{P_{VN}} = \frac{i^2 + \nu}{1 + \nu} \ge 1$$

⇒current load allowed:

$$i_{adm} = \sqrt{(1+v)\frac{1-e^{-(\tau_b+\tau_p)}}{1-e^{-\tau_b}} - v} \geq 1$$

with $\tau << 1$ and $T_b = T_p$:

$$i_{adm} = \sqrt{\frac{1+v}{\varepsilon} - v}$$

$$\frac{\Delta\vartheta_{\infty}}{\Delta\vartheta_{\infty N}} = \frac{P_V}{P_{VN}} \geq 1;\; i_{adm} = \sqrt{(1+v)\frac{\Delta\vartheta_{\infty}}{\Delta\vartheta_2} - v} \geq 1\ .$$

(d) Intermittent periodic duty with starting - Duty type S4. A sequence of identical duty cycles, each cycle including a significant period of starting, a period of operation at constant load and a rest and de-energized period (see Fig. 1.4)

Note - Periodic duty implies that thermal equilibrium is not reached during the time on load.

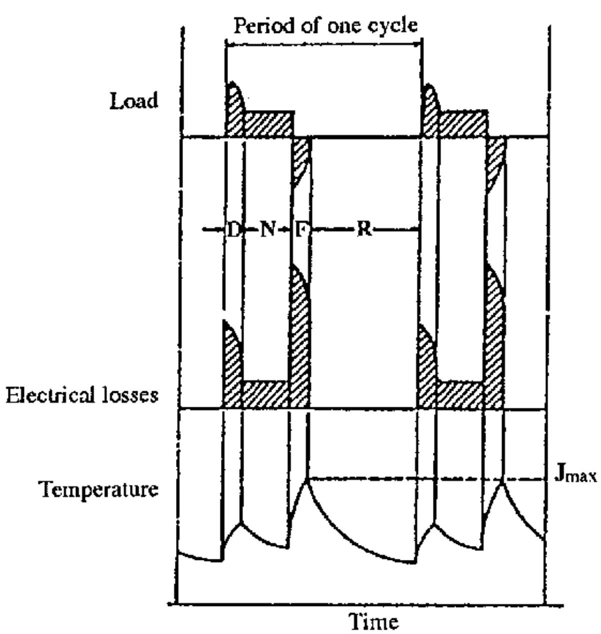

Fig. 1.4. Intermittent periodic duty with starting (S4)

KA is the Application Factor (it is closely related to Service Factor, but sometimes they are not used in same context).
It defines the load characteristic of the driven Machinery.

For instance, a shaker has a an application factor of about 1.8-2

A smooth conveyer drive would have KA = 1

The rated torque of gears is calculated with KA=1. The Neugart catalog is using it in this context.

Driving a machines can show dynamic variations (shocks): it is rather different to start a gear by means of an electric motor or a turbine than starting it by a multi-cylinder or single-cylinder internal combustion motor. On the other hand, driven machines work in very different dynamic conditions. Let us consider a ball mill and a belt conveyor for package: their working is completely different even if their nominal capacity is equal.
The application factor is represented by K_A. It considers all above-mentioned differences.
In the case of an application that incorporates a load spectrum, it is possible to calculate the gear for a nominal power, which is different from the power equivalent to the load spectrum following Miner's rule. If we know the load spectrum and we apply Miner's equivalent load, the value of the application factor will be equal to 1. If we know the value of the equivalent load of the spectrum and if we apply a rating load, the application factor will be given by the relation of the equivalent load to the rating load. The application factor is chosen empirically on the basis of the experience gained after having studied a particular machine type.