

EUROMAP 60.1	Injection Moulding Machines Determination of Machine Related Energy Efficiency Class
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12 pages

This recommendation was prepared by the Technical Commission of EUROMAP.

History

Date	Changes
April 1995	1st edition of EUROMAP 60 (Version 1.0)
June 2009	2nd edition of EUROMAP 60 (Version 2.0)
January 2013	3rd edition of EUROMAP 60 (Version 3.0) Completely revised – splitting in two parts: Part 1: Determination of Machine Related Energy Efficiency Class Part 2: Determination of Product Related Energy Consumption

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1 Introduction

1.1 Scope and application

This recommendation specifies the determination (measuring/calculation) of a classification based on the

- specific energy consumption and
- idle characteristics

for the description of the energy efficiency of injection moulding machines without regarding tool or customer influences for comparison reasons.

This recommendation covers injection moulding machines

- for the processing of thermoplastics
- with single injection unit,
- single screw, and
- electrical barrel heating
- which are able to process PP (see test material)

NOTE Only machines of similar sizes (screw diameter, clamping force ...) may be compared to each other in terms of energy consumptions (kWh/kg) and efficiency classes.

For the determination of the absolute/specific energy consumption of complex installation as well as for measuring according to customer requirements EUROMAP 60.2 shall be used.

This recommendation enables the evaluation of basic machines without considering ancillary movements, ancillary equipment or auxiliary units, so that the energy efficiency of the following main units should be ascertainable:

- drives
- electrical barrel heating (with barrel insulation)
- switchboard/control panel

The following shall is excluded:

- energy for the actuation of tools / tool cooling
- energy for material transport / improvement of material properties (e.g. dryers)
- pneumatic energy
- energy for ancillary equipment (robots, metering devices, ...)
- cooling medium energy for the machine (heat content)

For detailed requirements see clause 3.

1.2 References

Short name	Title	Version
EUROMAP 6	Injection Moulding Machines – Determination of the duration of the dry cycle	2007-01
EUROMAP 7	Injection moulding machines – Determination of the maximum clamping force	1995-05
EUROMAP 60.2	Injection Moulding Machines – Determination of Product Related Energy Consumption	2013-01
IEC 62053-22	Electricity metering equipment (a.c.) – Particular requirements – Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)	2003-01
VDMA 24470-1	Maschinen zum Verarbeiten von Kunststoffen und Kautschuk – Fähigkeitsnachweis bei Spritzgießmaschinen – Teil 1: Qualitätsrelevante Parameter	2007-05

2 Definitions

2.1 Total (electrical) energy consumption

Total electric energy consumption of the machine, based on the effective power (see figure 1), using a measuring method as specified in clause 4.

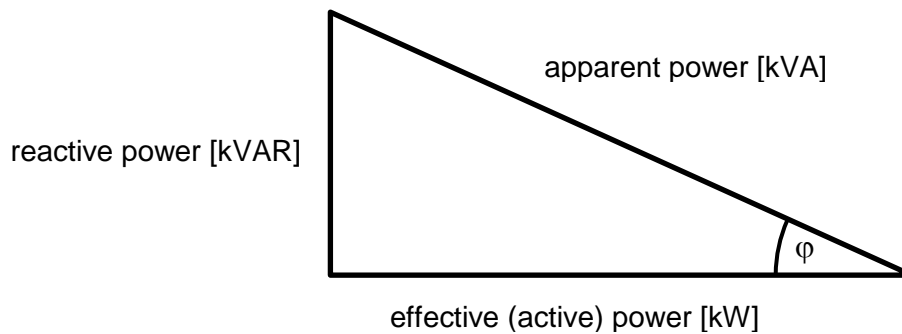


Figure 1: Power diagram

2.2 Machine related specific energy consumption

Total electric energy consumption as defined in 2.1 divided by the injected mass.

2.3 Ready-to-operate machine

All units (i.e. possibly required ancillary units, servo inverters, control ...) required for maintaining of the main machine movements (mould closing/opening, locking/unlocking, clamping/unclamping, ejection, metering, injection, applying/maintaining of contact force, lifting) are ready-to-operate. The heating is switched off.

2.4 Idle power

Idle power is the determined effective electrical power consumption of the ready-to-operate machine.

3 Energy consumers

The following shall be included:

- all drives and external hydraulic units for the main movements (see clause 2.3)
- ejector movements with no load
- controls
- internal maintenance devices (supplied by the machine manufacturer), e. g. cooling of electrical components, grease systems, cooling of the hydraulic oil
- heating of barrel (nozzle and flange included)

The following shall be excluded:

- nozzle contact force
- movements of the injection unit
- energy consumption of ancillary equipment, e.g. conveyors, hot runners, metering equipment, connected to plugs on the injection moulding machine
- pick and place devices connected to the machine controls
- other ancillary equipment
- external supply of fluids, e.g. cooling water, compressed air, hydraulic oil.

4 Measuring method

The information provided according to this recommendation shall be obtained through reliable, accurate and reproducible measurement procedures that take into account the recognised state-of-the-art measurement methods.

4.1 Measuring equipment

The power measurements shall be performed using instrumentation compliant to the IEC 62053 family of international standards. More specifically, the instrumentation shall be certified accordingly to IEC 62053-22:2003.

4.2 Test material

The test shall be carried out with virgin PP with MFR = 20 ... 25 g/10min (230°C/ 2.16 kg), not dried and not preheated, at an ambient temperature below 30°C.

4.3 Melt quality

The melt shall show no visual inhomogeneity, gassing or degradation.

4.4 Preparation of the injection moulding machine

The measuring shall be carried out using an adjustable nozzle as shown e.g. in figure 2 or 3. The manufacturer shall ensure that prior to the targeted injection through choice of suitable locking mechanisms (e.g. shut-off nozzle) the dosed volume is actually available for injection.

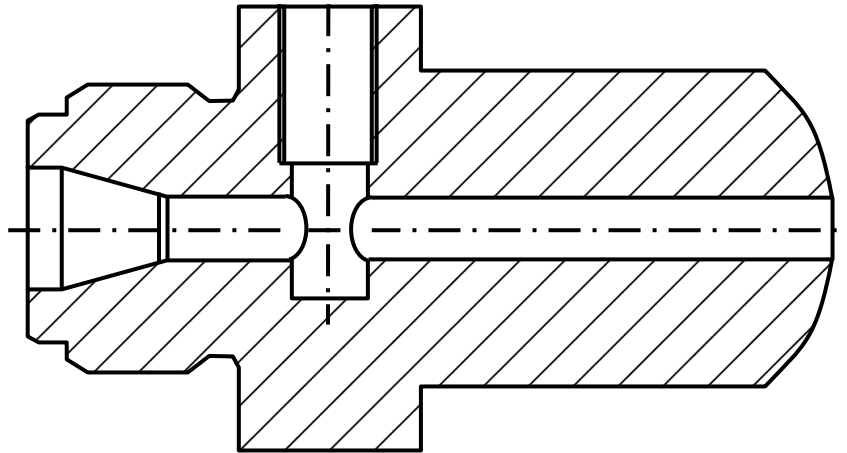


Figure 2: Test nozzle, type 1 (shut-off device not shown)

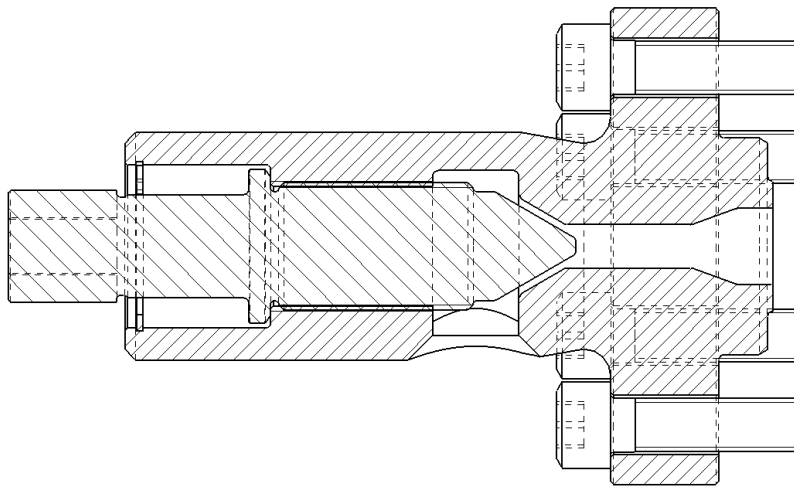


Figure 3: Test nozzle, type 2 (shut-off device not shown)

A test block (e.g. according to EUROMAP 7) shall be mounted on the fixed platen.

The barrel shall be equipped with barrel insulation.

The barrel set temperature of all zones shall be $220\text{ °C} \pm 5\text{ °C}$ (see VDMA 24470-1)

The main focus is on the standard machines listed in leaflets of the manufacturer. Therefore if a value according to EUROMAP 60.1 is provided, the customer may assume that it is determined

- with the equipment listed in the leaflet,
- if several injection units are listed: with the medial injection unit size,
- if several screw diameters are listed: with the medial screw size,
- if several drive concepts are listed: with clearly specified drive concept per movement axis.

If only two injection units/screw diameters are listed, the energy consumption shall be determined with the bigger unit/screw size.

4.5 Measurement

Determination of the total machine related energy consumption as defined in 2.1 and the mass injected shall be carried out only in automatic mode when the machine has reached a stable condition, i. e.:

- stable automatic operation without the necessity of a manual intervention for at least 15 min
- for hydraulic machines: when a stable oil temperature (within specification) has been reached.

For the measuring the machine shall be operated according to the parameters given in table 1. For standard machines test cycle I shall be applied. For fast running machines, if an average injection speed of min. 250 mm/s can be reached, test cycle II may be applied.

The injected melt volume shall meet the requirements on the melt quality mentioned in clause 4.3.

Table 1: Test cycles

Parameter	Cycle I (standard machines)	Cycle II (fast running machines)
Clamping force	maximum	maximum
Opening stroke	According to the determination of the dry cycle time according to EUROMAP 6. If the opening stroke is different to EUROMAP 6, it has to be given with value.	According to the determination of the dry cycle time according to EUROMAP 6. If the opening stroke is different to EUROMAP 6, it has to be given with value.
Closing / opening speed	maximum (100%)	maximum (100%)
Acceleration / deceleration	maximum (100%)	maximum (100%)
Ejection	stroke: $\geq 50\%$ of maximum stroke, no load, maximum speed	stroke: $\geq 50\%$ of maximum stroke, no load, maximum speed
Metering speed	≥ 0.5 m/s	maximum (100 %)
Injection pressure [bar]	≥ 750	≥ 1000
Injection speed	$\leq 50\%$ of maximum	≥ 250 mm/s (average speed)
Injection volume	plasticised volume	plasticised volume
Injection time [s]	resulting	resulting
Metering stroke ¹⁾	= 2 d	= 1.5 d
Plasticising time [s]	resulting	resulting
Holding pressure ²⁾	$\geq 50\%$ of the injection pressure	$\geq 50\%$ of the injection pressure
Holding time [s]	5	0.5
Cooling time ^{1) 3)}	$\geq 2[s] + 0.2[s/mm] \cdot d$	≥ 0.5 [s]
Back pressure of melt [bar]	50	50
Decompression	≥ 2 mm	≥ 2 mm

¹⁾ d: screw diameter;

²⁾ simulated by moving against a fixed stop or using a shut-off nozzle;

³⁾ time between end of holding time and start of clamp opening.

Notes: Cycle times may include different movements performed at the same time.
All pressures are melt pressures. Internal measurement equipment of the machine shall be used.

4.5.1 Determination of shot mass

Two methods are allowed:

Method 1 – Measurement of shot mass:

The measurement shall include a complete number of consecutive shots within a time not less than 10 min and at least 5 shots. For machines with a screw diameter ≥ 80 mm 3 shots are sufficient.

Method 2 – Calculation of shot mass

As basis for the weight determination the theoretical mass per shot according to the following formula shall be applied:

$$\text{Mass per shot} = \text{dosed volume [cm}^3\text{]} \cdot 0.73 \text{ [g/cm}^3\text{]}$$

4.5.2 Energy measurement

The reproducibility shall be $\pm 2\%$.

Recommendation:

- Measuring of energy consumption in stable condition for at least 5 cycles.
- For accumulator driven machines at least 1 charging cycle.

For the measuring of the heating energy the change of the medial heating power shall be taken as a guide – the changing of the digital signal shall serve as measuring criteria; the permissible tolerance shall be $\pm 1\%$).

Recommendation: Measuring over 10-15 cycles.

The measuring time shall be at least 3 minutes.

4.5.3 Idle measuring

The measuring time shall be chosen so that there is a constant stable idle power signal – the changing of the digital signal ($\pm 1\%$) shall serve as measuring criteria.

5 Validation

5.1 Classes for machines with screw diameter ≥ 25 mm

According to the determined specific energy consumption the machine shall be assigned to one of the following classes:

Table 2: Efficiency classes

Class	Specific energy consumption [kWh/kg]
1	> 1.50
2	≤ 1.50
3	≤ 1.20
4	≤ 0.96
5	≤ 0.77
6	≤ 0.61
7	≤ 0.49
8	≤ 0.39
9	≤ 0.31
10	≤ 0.25

5.2 Classes for machines with screw diameter < 25 mm

Small machines mostly have a higher energy specific consumption than big ones due to technical reasons. This shall be taken into account for screw diameters $d < 25$ mm by applying the following factor

$$f = (25 \text{ mm} / d)^2$$

to the class boards given in table 2. This leads to the classes given in figure 4 and table 3.

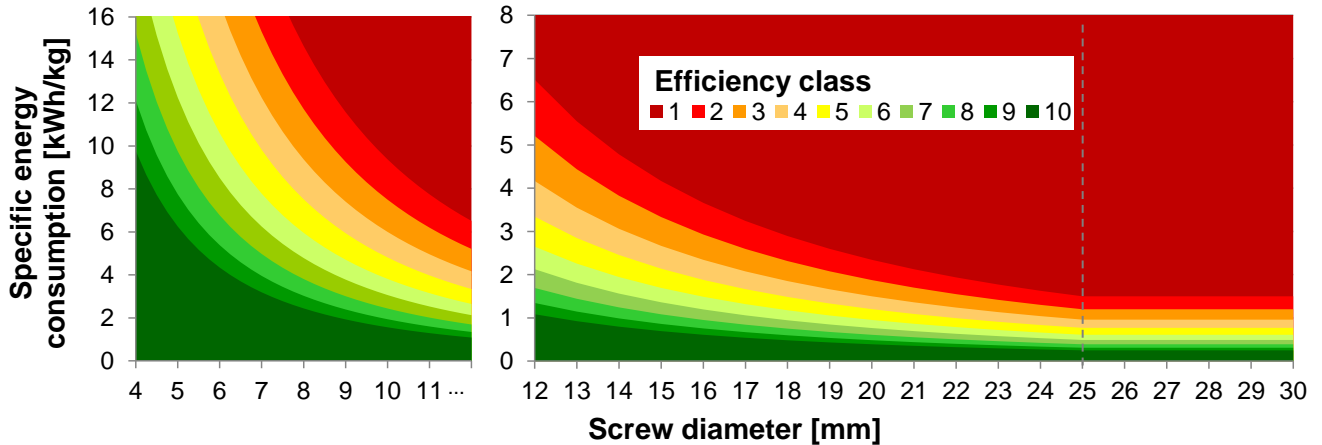


Figure 4: Efficiency classes for small machines

Table 3: Efficiency classes for small machines

Screw diameter [mm]	Max. specific energy consumption [kWh/kg] for efficiency class								
	10	9	8	7	6	5	4	3	2
24	0.27	0.34	0.42	0.53	0.66	0.84	1.04	1.30	1.63
23	0.30	0.37	0.46	0.58	0.72	0.91	1.13	1.42	1.77
22	0.32	0.40	0.50	0.63	0.79	0.99	1.24	1.55	1.94
21	0.35	0.44	0.55	0.69	0.86	1.09	1.36	1.70	2.13
20	0.39	0.48	0.61	0.77	0.95	1.20	1.50	1.88	2.34
19	0.43	0.54	0.68	0.85	1.06	1.33	1.66	2.08	2.60
18	0.48	0.60	0.75	0.95	1.18	1.49	1.85	2.31	2.89
17	0.54	0.67	0.84	1.06	1.32	1.67	2.08	2.60	3.24
16	0.61	0.76	0.95	1.20	1.49	1.88	2.34	2.93	3.66
15	0.69	0.86	1.08	1.36	1.69	2.14	2.67	3.33	4.17
14	0.80	0.99	1.24	1.56	1.95	2.46	3.06	3.83	4.78
13	0.92	1.15	1.44	1.81	2.26	2.85	3.55	4.44	5.55
12	1.09	1.35	1.69	2.13	2.65	3.34	4.17	5.21	6.51
11	1.29	1.60	2.01	2.53	3.15	3.98	4.96	6.20	7.75
10	1.56	1.94	2.44	3.06	3.81	4.81	6.00	7.50	9.38
9	1.93	2.39	3.01	3.78	4.71	5.94	7.41	9.26	11.57
8	2.44	3.03	3.81	4.79	5.96	7.52	9.38	11.72	14.65
7	3.19	3.95	4.97	6.25	7.78	9.82	12.24	15.31	19.13
6	4.34	5.38	6.77	8.51	10.59	13.37	16.67	20.83	26.04
5	6.25	7.75	9.75	12.25	15.25	19.25	24.00	30.00	37.50
4	9.77	12.11	15.23	19.14	23.83	30.08	37.50	46.88	58.59

5.3 Marking of Machines with low idle power

A plus ("+") shall be added to the class, if cycle I is applied and the determined idle power is ≤ 1 kW for small machines with clamping force < 400 ton or ≤ 3 kW for large machines.

6 Indication of values

In technical documents the applied test cycle, the efficiency class according to the determined specific energy consumption and idle power shall be given.

Example for determined values:

Test cycle I, specific energy consumption 0.8 kWh/kg, idle power 0.9 kW

Indication of classification:

EUROMAP 60.1 (cycle I) efficiency class: 4+

If the opening stroke is different to EUROMAP 6, the stroke has to be given with value. Example with opening stroke 500 mm:

EUROMAP 60.1 (cycle I, os = 500 mm) efficiency class: 4+

EUROMAP

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