

ENERGY EFFICIENCY LABEL AND SCALE FOR CONVEYOR BELTS

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INTRODUCTION

Energy and resource management has become an increasingly important issue as the world addresses climate change and strives for carbon neutrality. Mining is still of fundamental importance for our changing economy and is increasingly relying on particularly energy-efficient technologies in extraction in order to achieve ambitious energy saving and sustainability goals. Compared to other technologies, belt conveyors are already very energy-efficient when conveying large masses, but energy consumption can still be significantly reduced by using optimised conveyor belts.

Commitment to sustainability

Continental is committed to the 2015 Paris Agreement. That means global warming will be limited to below 2 degrees Celsius compared to the pre-industrial era. To achieve this, the world economy must become carbon neutral. Environmental protection is an integral part of many companies' policy. Economy and ecology are not a contradiction in terms, but rather the basis for sustainable value creation. All our products should actively contribute to the protection of our environment and our resources. In production, we want to continuously reduce energy and water consumption, CO₂ emissions and the volume of waste, and we want to further increase the recycling rate for operational waste. In view of the increasingly scarce raw materials, the goal is to develop products and solutions that consume less energy and conserve natural resources – both in the manufacture and in the use of products. The influence of the construction of conveyor belts on the energy consumption of belt conveyors has been known for a long time and has been researched accordingly [1]. The test methods developed to determine the indentation rolling resistance, a measure of the energy efficiency of a belt, have found their way into European and Australian standards [2,3]. What has been missing so far, however, is a scale that enables the test results to be easily evaluated.

Resistance to the movement of belt conveyor

Many studies have shown that the indentation rolling resistance of the conveyor belt is the decisive factor for energy consumption, particularly in the case of long belt conveyors. In conveyor belt technology, the development of energy-saving belt constructions was and is one of the most important development goals. When a conveyor belt runs over a support roller, the cover plate of the belt on the running side in particular is deformed. This deformation of the rubber is subject to friction, so that part of the kinetic energy is converted into heat. Special rubber compounds for the running side of a conveyor belt can reduce the energy consumption of a belt conveyor by up to 30% by minimising the friction inherent in the material. Additional energy savings can be achieved, for example, by optimising the idler distance and idler diameter of the belt conveyor.

Indentation rolling resistance in a highly simplified manner and following the approach to using friction coefficients (f-value) established in the design of belt conveyors, indentation rolling resistance (ERW) can also be regarded as a type of friction resistance. In contrast to conventional friction, however, it is not linear, but increases slightly disproportionately with increasing load (Figure 1).

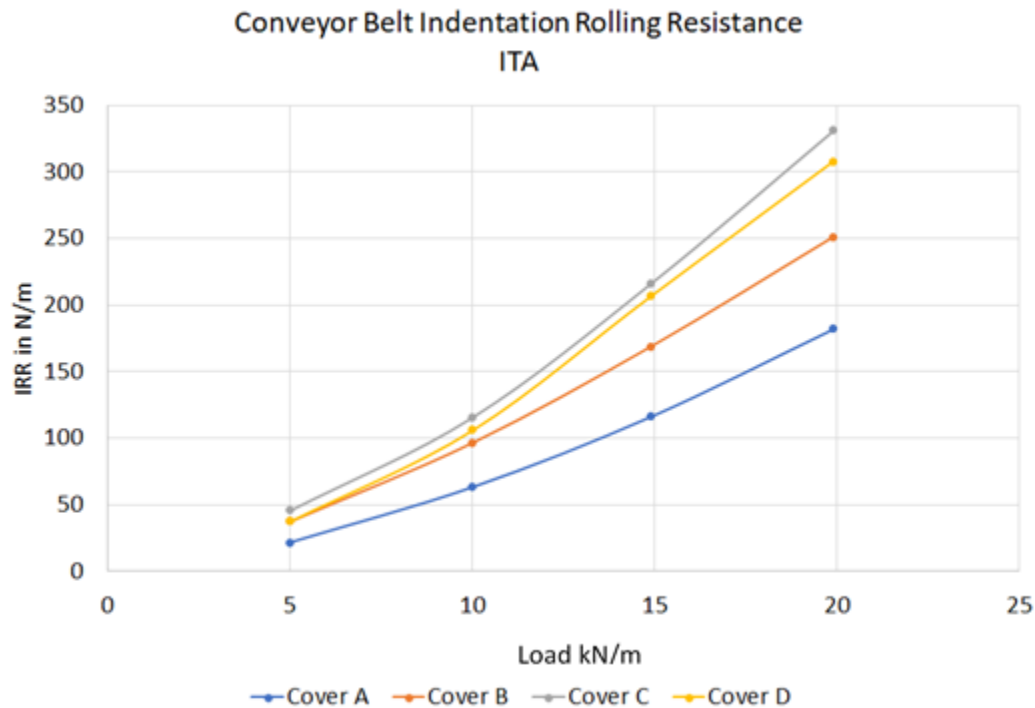


Figure 1: Width-related indentation resistance of conveyor belts with different rubber compounds on the running side, depending on the load

In addition to the respective size of the normal forces distributed on the idlers as a line load, their distribution along the idler shell is of decisive importance for the calculation of the indentation rolling resistance acting on an entire set of idlers. In the area of the nominal loading of belt conveyors, a simplified model can be used, which is characterised by a constant normal force curve along the centre idler and by a normal force curve that increases linearly in the direction of the centre idler along the side idlers [4].

Figure 2 schematically shows the idealised distribution of the normal forces and the resulting indentation rolling resistance for a horizontal and straight belt conveyor.

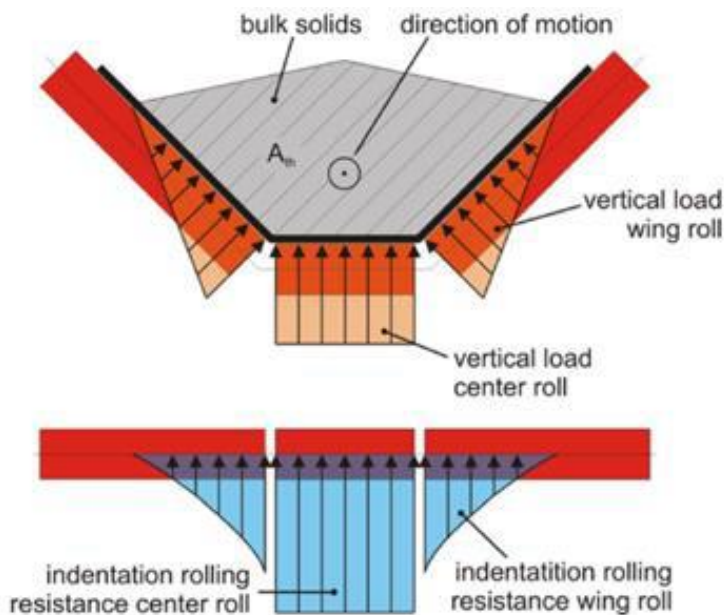


Figure 2: Idealised distribution of the normal forces along the idlers and the resulting indentation rolling resistance components on a horizontal and straight belt conveyor [4]

Energy Efficiency Scale for Conveyor Belts

Due to increasing global awareness of the need to save energy, the demand for energy efficient products has increased and most conveyor belt manufacturers now offer energy efficient conveyor belts. As already mentioned, there are standardised test methods for determining the indentation rolling resistance and thus for the energetic evaluation of different belts, but a direct comparison was hardly possible due to the often different test parameters and design features of the belt. In order to make consumers more aware of energy consumption, the EU has introduced energy efficiency labels (EE labels) for many products, which enable consumers to rate the energy efficiency of each product on a standardised reference scale. Many product labels have the same format for this scale. The scale is divided into seven levels, with each level identified by a letter in a coloured bar and energy efficiency by the rating letter that colour, and the length of the bar is specified as shown in picture 3. An A rating in a short green bar represents the most energy efficient product variant, and a G rating in a long red bar indicates the least energy efficient product variant. Examples of such labels can be found on tyres, household appliances, light bulbs, etc.

Energy Efficiency Label for Conveyor Belts

The standardised conveyor belt energy efficiency scale of ARPM [5], created in cooperation with their conveyor belt manufacturers, is shown in Figure 3.

Energy Efficiency Rating					
Conveyor Belt Energy Efficiency Scale	EE Friction Factors		IRR (L = 5kN/m)		Rating
	F/L (N/kN)		(N/m)	(N/m)	
Very energy efficient - lower running costs	Low	High	Low	High	
A	0.0	10.0	0.0	50.0	A
B	10.1	13.0	50.5	65.0	B
C	13.1	16.0	65.5	80.0	C
D	16.1	20.0	80.5	100.0	D
E	20.1	25.0	100.5	125.0	E
F	25.1	30.0	125.5	150.0	F
G	30.1	35.0	150.5		G
Not energy efficient - higher running costs					

Figure 3: ARPM energy coefficient friction table. Equivalent ERW values for a vertical load of 5 kN/m

Explanations for the table in Figure 3:

Column 1: ARPM energy efficiency scale Column

2: Low values of energy efficiency factors (N/kN) for each level (rating) Column

3: High values of energy efficiency factors (N/kN) for each level (rating) column

4: Low ERW values (in N/m) at a vertical test load of 5 kN/m Column

5: High ERW values (in N/m) at a vertical test load of 5 kN/m Column

6: Alphabetical ratings 'A ' to 'G'

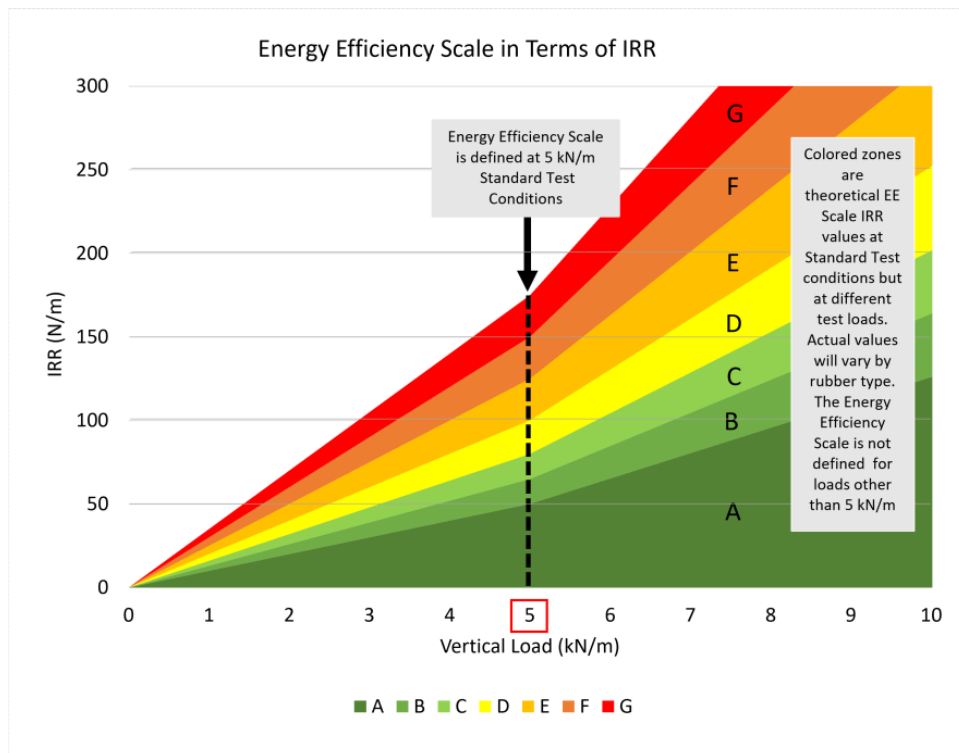


Figure 4: Energy efficiency scale in the ERW diagram for width-related load

Figure 4 illustrates the ARPM energy efficiency scale [5] using the typical curve for the determined ERW test results, in which the information on rolling resistance in N/m is recorded against the vertical test load (kN/m). The standardised load for determining the indentation rolling resistance is 5 kN/m, the limit values of the indentation rolling resistance result for this load according to Figure 4. Values for other vertical loads are not defined. The values presented in Figure 4 at other vertical loads are approximate values based on theoretical analysis from ERW research studies and are consistent with "typical" test data. The actual values vary depending on the properties of the rubber compounds tested. This approach is basically the same as the EE marking of tyres.

Test method for determining the indentation rolling resistance

The ARPM energy efficiency scale for conveyor belts is based on the indentation rolling resistance (ERW) determined in standardised test methods. The approved test methods are defined in the following national standards: 1. ISO23586 2. AS1334.13-2017 3. (DIN EN 16974). Due to minor differences in these methods, ARPM requires that the test method and conditions are stated on the test data label. Due to the significant temperature dependence of indentation resistance and the fact that conveyor belts are used over a wide temperature range, ARPM requires the test to be performed at four temperatures: -20°C, 0°C, 20°C and 40°C.

These cover typical operating ranges of most conveyor belts. Additional test temperatures would be required for higher or lower temperature applications. However, test facilities typically do not test below -40°C.

ARPM test conditions

Two types of ARPM test conditions are defined: Type A and Type B. The type "A" test has standardised test conditions (Fig. 5) and standardised test belt constructions for steel cord belts (Fig. 5) and for textile belts (Fig. 6). The "A" type test is to be used to compare different belt constructions.

Type A examination
1 Belt speed: (5 m/s)
2 Roller diameter: (152.4mm)
3 Vertical load: (5 kN/m)
4 Standard belt constructions: steel & fabric
5 Test temperatures: (-20°C, 0°C, 20°C, 40°C)
6 Belt sag: (if applicable)

Figure 5: Type A - standard test conditions

Steel cord belts

- 1 Belt Strength (Nominal): ST1000
- 2 Steel cord diameter: 3.6 mm
- 3 Rope pitch: 12.0 mm
- 4 Thick top face: 8.0 mm
- 5 Thick running side: 8.0 mm
- 6 Top and bottom quality: same mixture
- 7 No transverse reinforcement in the top and running sides

Figure 6: Standard belt construction St belts

Textile belts

- 1 Breaking strength of each fabric layer: 175 to 350 N/mm
(1000 to 2000 PIW)
- 2 Weave: Plain or Twill weave
- 3 Number of layers of fabric: 2 layers
- 4 Thickness top face: 3.0 mm
- 5 Thickness underside: 3.0 mm
- 6 Quality top face and underside: same compound
- 7 No transverse reinforcement on the top face

Figure 7: Standard belt construction of TX belts

Type "B" tests can have a non-standard test belt and/or non-standard test conditions (Figure 8). Type B tests often represent specific application conditions.

After discussions in the ARPM working group, it was agreed that the same scale should be used for type B tests, i.e. with possibly different belt construction and different test conditions. In this case, the scale shows the most efficient options, taking into account changed test conditions. Example: A Type A belt design tested under Type B test conditions, where the only change is a larger idler diameter, shows better efficiency characteristics. Number of Samples: As with tyre energy efficiency testing, only one sample is tested. In the event of an unexpected or controversial result, two additional samples are tested and an average of the three samples is calculated.

Criteria for deciding on the Type A and Type B tests:

Type A

- Specification of all test conditions including the belt construction
- Comparison of energy-efficient rubber mixtures from different conveyor belt manufacturers
- Ideal method for fundamentally comparing belts from different manufacturers

Type B

- No specified belt design
- Best method to determine the influence of a combination of parameters on the efficiency of the conveyor system
- Best method to measure the influence of the idler diameter on the energy efficiency
- Ideal method, for example, to combine belts in the context of a larger project under application-specific conditions to compare

ARPM label

The following components are contained in an ARPM energy efficiency label:

1. Test method (ERW 'Large Scale' - ARPM Type A or Type B)
2. Date of EE marking
3. Test facility or institute
4. Country in which the test took place
5. Date of certification
6. Reference number for traceability
7. Designation of the tested belt (type and number of fabric layers or diameter and pitch of the steel cords)
8. Name of the conveyor belt manufacturer
9. Reference method (e.g. DIN 22123 :2012, ISO 23586, AS 1334.13:2017)
10. Test conditions
11. Reference colour scale labeled A to G
12. Section with EE factors at each temperature

Figure 9 shows a typical layout for an ARPM energy efficiency label for a Type A belt sample. The values in the black box indicate the actual values (ERW in N per applied load in kN) achieved at each of the four standard test temperatures during testing. These values allow for a more detailed comparison within each category. The overall

limits of the scale reflect the full range of measured values for all compound types. In general, rubber compounds designed for heat, flame or oil resistance often only achieve their primary functional properties at the expense of changing other properties such as tensile strength, elongation and/or energy efficiency. The ARPM Conveyor Belt Efficiency Label provides an easy-to-understand reference scale that gives end-users a tool to make more informed purchasing decisions to better guide their energy reduction goals.

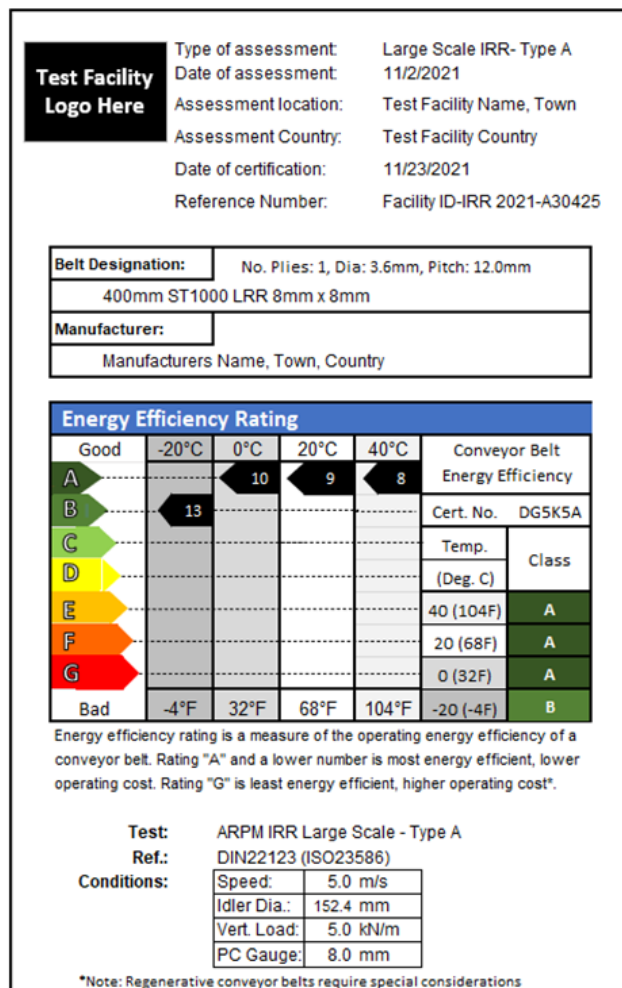


Figure 9: Example of a conveyor belt energy efficiency label

Energy efficiency application example Customer:

Wesfarmer North Curragh, CV1103, Australia Horizontal length/elevation: 20 km/64 m Belt type: Flexsteel 1200 ST1500 - 7/5 Eco Extreme. By using extremely energy efficient conveyor belts compared to standard conveyor belts, a reduction in investment costs of 39% and a reduction in operating costs of 41% can be achieved. In detail, by using an Eco Extreme conveyor belt, the resistance to movement and thus the required belt tension could be reduced, so that an ST1500 could be used instead of an ST2500. With the use of an Eco Extreme pulley side cover the DIN f value was determined as $f = 0.0083$ [6].

CONCLUSION

Since year 2021, our company has been campaigning for an energy efficiency label for conveyor belts in national standards worldwide and is represented in the standards committees of these countries. We have made the same proposal in all bodies, and we strongly advocate that all standards refer to the same scale.

The presented energy efficiency label

1. provides a standardised scale for quantifying and comparing the indentation resistance of conveyor belts,
2. Provides a simple tool to quantify and visualize what level of energy efficiency is being achieved in an easy to understand, colour coded 7-point scale,
3. Provides a simple tool to set targets for improving energy use, saving costs and reducing greenhouse gas emissions,
4. Provides green businesses and governments with a tool to quantify and improve the energy efficiency of conveyors to achieve sustainability goals.

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