CONVEYOR MANUFACTURERS ASSOCIATION
OF SA LIMITED

GENERIC SPECIFICATION FOR GEARED REDUCERS FOR CONVEYORS

CMA MR01 Rev05 2011

INDEX

ITEM **Page**

1. SCOPE

This specification covers the general technical requirements for gear reducers for use on belt conveyors. Standard terminology for the specification of reducers is defined. Note that the standardised requirements for units conforming to the “Euro” standard are not specifically covered by this specification. Because of their special nature, gear units that are dependent on external reductions (such as vee drives or chain) to achieve their speed reduction (the “SMSR” type of reducers) are excluded from this specification.

2. GEARS

The basic requirements for mechanical speed reducers by means of gearing may be summarised as follows :

2.1. Gear Ratio

In order to achieve the desired output speed, the reduction ratio of the reducer shall be specified by the user, in accordance with the range of ratios as offered by the supplier. The exact ratios of the reducer unit shall conform to the standard nominal ranges within a tolerance of ±5%. Tables 1 and 2 list the standard range of ratios in ISO and AGMA. The ISO range utilises the R20 number series, while the AGMA range utilises a geometric progression with $\sqrt{1{,}5}$ as the common ratio.

10	11,2	12,5	14	16	18	20
22,4	25	28	31,5	35,5	40	45
50	56	63	71	80	90	100

TABLE 1: SELECTED STANDARD NOMINAL RATIOS
IN ACCORDANCE WITH ISO R20

6,2	7,6	9,3	11,4	14,0	17,1	20,9
23,2	25,6	28,4	31,4	34,7	38,4	42,5
47,1	52,1	57,7	63,8	70,6	86,5	105,9

TABLE 2: SELECTED STANDARD NOMINAL RATIOS
IN ACCORDANCE WITH AGMA

2.2 Tooth Profile and Gear Strength

The gear tooth profile and the load capacity of gear pairs shall be determined in accordance with the ISO or AGMA group of standards, provided that the allowable material stresses are comparable. Cognisance shall be taken of advances in material technology.

3. GEAR SHAFTING

3.1 Gear shaft material shall be appropriately selected and shall be designed to be rigid, in order to minimise clearances between gear pairs when operating under full load. Applicable stress concentration factors shall be catered for as required.

3.2 The surface texture on the protruding shafts and the bore of hollow shafts shall be in the following ranges

3.2.1 For bore or shaft diameters ≤100 mm; R_a = 0,8 μm (N6).

3.2.2 For bore or shaft diameters >100 mm; R_a = 1,6 μm (N7).

3.2.3 For all cases where a rigid coupling is specified, R_a = 0,8 μm (N6).

3.3 Keys and keyways for protruding shafts and for hollow shafts (not fitted with keyless systems) shall conform to BS 4235 and DIN 6885. Tapped holes in shaft ends shall comply with the requirements of DIN 332/2

3.4 In the case of shaft-hung reducer sets equipped with rigid output couplings, it may be preferable for the output shaft of the reducer to be increased in diameter and reduced in protrusion length, in order to reduce the imposed overhung loading component. In this case, the user should consult the supplier, as appropriate.

3.5 In the case of shaft-hung reducer sets equipped with rigid output couplings, the tolerance on the diameter of the reducer output shaft shall be as specified by the rigid coupling manufacturer. The shaft shall be supplied without a keyway, unless otherwise specified by the user.

3.6 Where shafts are not required to protrude beyond the reducer casing, they shall be securely sealed by means of end caps or plates. Protruding shafts shall be sealed against the ingress of dirt and moisture, using advanced sealing technology, such as regreasable seals, as appropriate.

4. GEAR CASINGS

4.1 The gear casing shall be designed and constructed to minimise deflection and distortion under full load and under maximum temperature operating conditions.

4.2 The casing shall be designed to withstand the combined effects of the radial, axial and overhung loads imposed. The casing shall be provided with lifting facilities, suitably located and proportioned. Where a reducer casing is split and/or invertible, the lifting facilities shall be provided on both halves of the casing.

4.3 The gear casing shall be provided with a properly dimensioned drain system and an easily accessible oil filling port, with an easily accessible oil level monitoring system, by means of either a dip stick or sight glass (or both), or level plug.

4.4 The filter requirements shall be in accordance with contaminant levels in the environmental and operational conditions.

4.5 Identification

The gear casing shall be provided with a nameplate, securely attached to the casing and indicating the following:

4.5.1 The nominal reducer power rating, based on a service factor of 1. In addition, the reducer torque rating may be indicated.

4.5.2 The reducer ratio. The ratio indicated may be either nominal or exact and shall be identified accordingly.

4.5.3 The reducer size designation in accordance with the supplier’s convention.

4.5.4 The lubrication specification, with regard to oil type, grade and fill quantity.

4.5.5 A traceable serial number for the gear reducer assembly.

5. LUBRICATION

5.1 The reducer shall be designed so that all the internal moving parts are adequately lubricated, by means of splash, scoop, channel or pump forced lubrication, as appropriate.

5.2 The type and grade of lubricant shall be determined by the supplier, in conjunction with the user.

5.3 The design of the installation or system shall limit the reducer sump running oil temperature to a maximum of 90°C when using mineral oils. Higher temperatures could be obtained with synthetic oils, but that would be subject to agreement between user and supplier. The addition of fans, cooling coils or external radiators shall be determined in collaboration with the end user. Other oil temperature limitations may be imposed for particular applications.

5.4 Should the unit not be supplied with a first fill of oil, then a further label shall be affixed to the reducer clearly indicating that the reducer has no oil. The label may indicate the oil grade and quantity for the first fill.

5.5 Normal Ambient Temperature.

For sub-Saharan Africa and particularly for Southern African conditions, the normal ambient temperature is considered to be in the range 30°C to 40°C. The ambient operating temperature should be determined in conjunction with the user.

6. TERMINOLOGY

6.1 The standard definitions relating to power are listed in Table 3.

Term	Definition
Absorbed Power	The power seen by the output shaft of the reducer. This power is derived from the conveyor itself and is normally given by the effective tension (kN) multiplied by the conveyor belt speed (m/s). $T_e \times S = P_{abs}$ (kW)
Demand Power	The power required at the motor shaft. This power is derived from $P_{demand} = \frac{P_{in}}{\eta_{cplg}}$ (kW) where P_{in} is the input power and η_{cplg} is the input coupling efficiency
Reducer Rated Power	The *unfactored* mechanical capability of the reducer. This is usually available in the power tables published by the manufacturer.
Installed Power	The electrical power or nameplate power of the motor. Designated P_{mot} it is normally the next larger size of motor compared to the Demand Power.
Design Power	The power derived, *including* factors, for comparison with the Reducer Rated Power. Thus $P_{red} = \frac{P_{abs} \times SF}{\eta_{red}}$ (kW), where SF is the appropriate service factor.
Input Power	The power required at the reducer input shaft. This power is derived from $P_{in} = \frac{P_{abs}}{\eta_{red}}$, where η_{red} is the reducer efficiency.
Thermal Power	The power derived by the manufacturer and published as the Thermal Power Rating of the reducer. This rating is affected by several factors, such as the addition of fans, external cooling, the radiation coefficients of the reducer casing and the ambient conditions.

TABLE 3: COMMON TERMINOLOGY RELATING TO REDUCERS FOR CONVEYORS

6.2 The mechanical power ratings shall be at least based on 2-pole, 4-pole and 6-pole synchronous motor speeds. For variable speed drives, the mechanical power rating shall be based on the most arduous power/speed condition.

6.3 The thermal power rating of the reducer shall be determined in order to limit the temperature rise of the oil to a maximum of 60°C above ambient conditions, as defined in 5.5 above, with a maximum of 90°C. The thermal power shall be at least equal to or greater than the absorbed power.

6.4 Mineral oils subject to temperatures above 90°C tend to break down more rapidly and will require more stringent oil condition monitoring and more frequent oil changes. For variable speed drives, the thermal power rating shall be based on the most arduous power/speed condition.

7. SERVICE FACTORS

7.1 The power rating of the reducer is normally determined by the lowest rating for any bearing or gear pair for either bending or pitting. These criteria shall be covered when determining the service factor.

7.2 The service factors (SF) shown in Table 4 would apply as the general case and are based on 24 hours operation. Other service factors could be applied by individual users, but these would have to be ratified by the supplier.

Loading	Description	Service Factor
Uniform	Up to 24 h/day. Uniform loading. Light/medium duty plant conveyors, Normally single drive options only.	$SF = 1{,}25 = \frac{P_{red}}{P_{abs}}$ or $SF = 1{,}00 = \frac{P_{red}}{P_{mot}}$
Moderate	24 h/day. Cyclic or moderate shock loads. Bucket wheel reclaimer conveyors. Heavy duty plant or overland conveyors and conveyors with multiple drives. All underground conveyors.	$SF = 1{,}50 = \frac{P_{red}}{P_{abs}}$ or $SF = 1{,}25 = \frac{P_{red}}{P_{mot}}$
Load-sharing	24 h/day. Dual independent drives for conveyors other than variable frequency driven units. Increase factor 1,20	$SF = 1{,}80 = \frac{P_{red}}{P_{abs}}$ or $SF = 1{,}50 = \frac{P_{red}}{P_{mot}}$

TABLE 4: TYPICAL STANDARD SERVICE FACTORS

7.3 Where conveyors are equipped with 2, 3 or 4 power packs in a 1/1 or 2/1 dual independent drive arrangement with fluid couplings, the Service Factors may be increased by a factor of 1,2 to cater for uncertain load-sharing. In this case, the SF for moderate loading may be altered as shown in table 4. It must be noted that the increase in service factor will result in a higher specification of reducer and the application of the increased SF should be subject to agreement between the user and the supplier.

7.4 Care must be exercised when specifying the Service Factor with respect to the motor nameplate power, since an oversized motor (as a result of rationalisation or other aspects) may result in a significantly oversized reducer. Alternatively, should the reducer be selected on the basis of design power with the relevant SF, then an oversized motor may prove destructive.

7.5 When the value of the service factor approaches or exceeds 3, the reducer bearing life could be adversely affected and the final reducer selection should be referred to the supplier.

7.6 The service factor has traditionally been related to the wear life, or the useful service life of the whole reducer, with due cognisance taken of the individual component life. The service factors are therefore largely empirical and have been compiled by experience. Tables for service factors are available from several sources and there is little difference in the service factor for machine categories and operating periods as determined by ISO, AGMA and other authorities.

8. BEARING SELECTION

8.1 The minimum basic rating life of the bearings used in conveyor reducer drives calculated according to the ISO 281:2007 standard shall exceed 40,000 hrs.

8.2 The equation used to determine the basic rating life of a bearing according to the ISO 281:2007 standard is as follows:

$$L_{10h} = \frac{1000000}{60n} (C/P)^p$$

where

L_{10h} - basic rating life (operating hours)
C - basic dynamic load rating of bearing (N)
P - equivalent dynamic bearing load (N)
n - rotational speed (rpm)
p - exponent of the life equation
= 3 for ball bearings
= 10/3 for roller bearings

8.3 For modern high quality bearings, the basic rating life can deviate significantly from the actual service life for specific operating conditions. ISO 281:1990/Amd 2:2000 contains an adjusted life equation which includes life adjustment factors for reliability, lubrication and the fatigue limit of the bearing material. ISO 281:2007 contains a modified rating life equation which includes modification factors for reliability, bearing material, lubrication (type of lubricant, viscosity, bearing speed, bearing size), environment (contamination level, seals), contaminant particles (hardness and particle size in relation to bearing size, lubrication method, filtration) and mounting (cleanliness during mounting).

8.4 The equation (a_{iso}) used to determine the adjusted rating life of a bearing according to the ISO 281:1990/Amd 2:2000 standard is as follows:

$$L_{nah} = a_1 a_{23} L_{10h}$$

where

L_{nah} - adjusted rating life (operating hours)
a_1 - life adjustment factor for reliability
a_{23} - life adjustment factor for material and lubrication
L_{10h} - basic rating life (operating hours)

8.5 The equation used to determine the modified rating life of a bearing according to the ISO 281:2007 standard is as follows:

$$L_{nm} = a_1 a_{ISO} L_{10h}$$

where

L_{nm} - modified rating life (operating hours)
a_1 - life adjustment factor for reliability
a_{ISO} - life modification factor
L_{10h} - basic rating life (operating hours)

8.6 In addition to specifying the calculated basic rating life (L_{10h}) for all of the bearings used in the conveyor reducer drive gearbox, the gearbox manufacturer can also specify calculated adjusted (L_{nah}) and/or modified (L_{nm}) rating lives to provide an indication of the effect of additional factors (reliability, lubrication, contaminant particles and mounting conditions) on bearing service life.

8.7 Should the gearbox manufacturer determine and include adjusted (L_{nah}) / modified (L_{nm}) bearing rating lives in the design specifications, the adjustment factors and resultant adjusted / modified rating lives shall be specified in the format depicted in Table 5.

L_{10h}	40,000
a_1	1
a_{23}	2.5
a_{iso}	2.5
L_{nah}	100,000
L_{nm}	100,000

TABLE 5: CALCULATED BEARING LIVES AND ADJUSTMENT / MODIFICATION FACTORS

8.8 Should the gearbox manufacturer determine and include adjusted rating lives or modified rating lives for the bearings in the design specifications, the operating variables used to determine the values of the a_{23} / a_{ISO} adjustment / modification factors shall be listed.

8.9 The a_1 life adjustment factor for reliability should not exceed 1 which is the reliability factor for the basic rating life (L_{10h}) calculation. Reliability can be defined as the percentage of a suitably large group of apparently identical bearings operating under the same conditions that can be expected to attain or exceed a specified life.

8.10 The a_{23} life adjustment factor is based on the lubricant film thickness within the bearing and is a function of the viscosity of the lubricant used and the bearing operating temperature. Selection of an appropriate lubricant, lubricant delivery system and effective cooling typically results in an a_{23} life adjustment factor which is greater than 1.

8.11 The a_{ISO} advanced life modification factor represents the relationship between the fatigue load limit ratio, the lubrication condition and the level of contamination in the bearing.

8.12 Table 6 below contains guideline values for contamination factors used in the determination of the a_{ISO} advanced life modification factor. The gearbox supplier may use any value for this factor as long as the value is representative of the actual conditions of the oil in the gearbox.

Guideline values for factor η_c for different contamination levels	**Typical values for d_m<100mm**	**d_m>100mm**
Extreme Clean oil – Laboratory conditions	1	1
Highly Clean Oil – Oil filtered through extremely fine filter	0.6 - 0.8	0.8 - 0.9
Normal Cleanliness – Oil filtered through fine filter	0.5 - 0.6	0.6 - 0.8
Slight contamination – Course filtration and no contamination ingress	0.3 - 0.5	0.4 - 0.6
Normal contamination – Wear particles and environmental particles in oil	0.1 - 0.3	0.2 - 0.4
Heavy contamination – High environmental particle ingress and insufficient sealing	0 - 0.1	0- 0.1

TABLE 6: GUIDELINE VALUES FOR CONTAMINATION FACTOR

9. MOUNTING AND ALIGNMENT

9.1 The reducer, motor and coupling assembly shall be mounted on a baseplate that is designed in a one-piece construction. The baseplate shall be designed to minimise deflection and twisting while under load. The baseplate may be cast or fabricated, as required. The baseplate shall be stress-relieved before final machining.

9.1.1 Where the motor is flange-mounted onto the reducer, either directly or by means of a lantern-ring to house the high speed coupling, the reducer casing shall be designed to cater for the imposed loads without bending, distortion or twisting. See also 4.1

9.2 The foundations or support steelwork for the reducer baseplate assembly shall be level and square, with provision for packing or shimming as necessary during installation, to achieve proper alignment.

9.3 In the case of a shaft mounted or shaft hung assembly, the baseplate shall be designed to withstand the torque developed during starting and stopping cycles of the conveyor. See also 9.1.1

9.4 Where torque arms are required, the installation tolerance of the torque-arm mounting bracket shall be within 1,0 mm in any horizontal direction. The torque arm and bracket assembly shall be designed to be suitably flexible in order to cater for such installation inaccuracies and to provide cushioning of transient loads and the loads during starting and stopping of the conveyor.

9.5 In the case of shaft-hung units equipped with rigid couplings, the installation tolerance on each coupling flange face shall be limited to 0,03 mm per 100 mm diameter of the coupling flange. Speed related relaxation of the installation tolerance shall be subject to negotiation between the user and the supplier. The coupling mounted on the conveyor drive pulley shaft shall be subject to the same installation tolerance. It must be noted that the deflection of the conveyor pulley shaft must be considered under full load conditions and that this shall be catered for in the installation of the shaft hung unit.

(Note. While the installation tolerance recommended by reputable coupling manufacturers is quoted as 0,01 mm per 100 mm diameter of the coupling flange, the value suggested in the specification includes an allowance for reducer output shaft bearing end float and clearances).

9.6 Where rigid couplings are used, the convention is for the coupling half with the female spigot to be mounted on the reducer output shaft, while the coupling half with the male spigot is mounted on the conveyor drive pulley shaft.

9.7 Where rigid couplings are used, it is important that the coupling halves are match-marked upon final assembly and alignment, to facilitate removal and replacement.

9.8 In cases where fluid couplings are specified, the overhung load capability of the reducer input shaft should be ascertained. In the majority of cases, the couplings should be arranged such that the greater part of the coupling mass is carried on the motor shaft.

10. HOLDBACKS

10.1 Where a holdback is required to be fitted to the reducer, either internally or externally on a shaft extension, the system strength (gear tooth strength) shall be capable of the full holdback rating. Furthermore, the reducer shaft extension where the holdback is to be fitted shall have adequate strength rating to withstand the full holdback torque capacity.

10.2 Where the conveyor is equipped with multiple drives fitted with internally mounted holdbacks, either the rating of one holdback shall be adequate for the total run-back torque (with reference to paragraph 9.1) or the system shall be equipped with load-sharing type holdback units.

10.3 Holdback lubrication may be incorporated into the reducer system, without the need for external or separate lubrication systems. The grade of oil specified by the holdback supplier shall be compatible with the requirements of the reducer.

10.4 It must be noted that externally mounted holdbacks are available which are grease lubricated. These units can therefore not be lubricated by means of the oil in the gear unit and shall be clearly marked as such.

11. ACKNOWLEDGEMENTS

This specification was reviewed by a working group of representatives of **Anglo Technical Division** (representing User groups) together with CMA member companies
Canterbury Mining & Engineering cc.
Bauer, a Division of Hudaco Transmission (Pty) Ltd
David Brown Gear Industries (Pty) Ltd
Flender Power Transmission (Pty) Ltd
Hansen Transmissions (Pty) ltd and
Powerdrives, a division of Bearing Man Ltd
SEW Eurodrive (Pty) Ltd
representing reducer manufacturers, suppliers and bearing suppliers

Further revisions were conducted by CMA member companies:
Bateman
Bauer
Bonfiglioli
David Brown
Hansen
Renold Crofts
SEW
SKF

12. RECORD OF AMENDMENTS

Revision 01	Paragraph 3.2 Surface texture altered and expanded . Paragraph 4.5.5 added. Paragraph 5.4 added. Paragraph 9 expanded and sub paragraphs added.
Revision 02	Index and front cover added.
Revision 03	Table 4 modified to cater for dual independent drives Paragraph 7.2.1, 8.7 and 9.4 added.
Revision 04	General review
Revision 05	Adjusted Bearing Life

June 2011
Johannesburg.