SPECIFICATION DEVELOPMENT

GET THE RIGHT CONVEYOR DRIVE SYSTEM FOR THE JOB

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The selection of conveyor drive components is a comprehensive, investigative process involving input from multiple parties: facility management, corporate personnel, consultants and equipment suppliers, to name a few. Culling the knowledge and expertise of all individuals involved should result in the proper selection of conveyor drive components that prove durable, efficient and cost-effective to help achieve a facility's long-term production goals. **(Figure 1)**

But, during this involved selection process, are details overlooked? Do elements conflict? Are all parties "on the same page?" How can it be ensured that the appropriate conveyor drive equipment is selected and installed?

Specifications. It is the consistent communication document between the facility owner, consultants and suppliers **(Figure 2)** for proper equipment selection. Therefore, its development is paramount. Specifications define what is required of the complete conveyor system to provide an expected performance level.

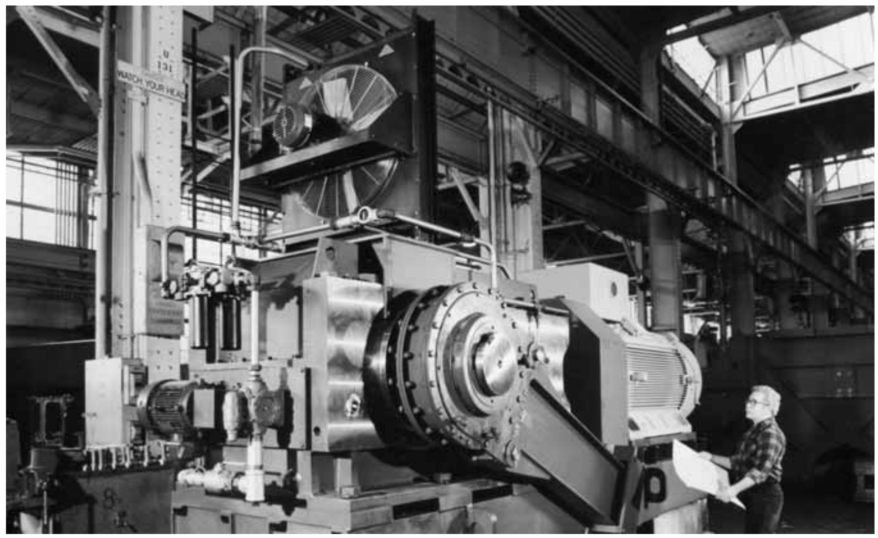

Figure 1 — A durable, efficient and cost-effective conveyor drive system will help a facility achieve its long-term production goals.

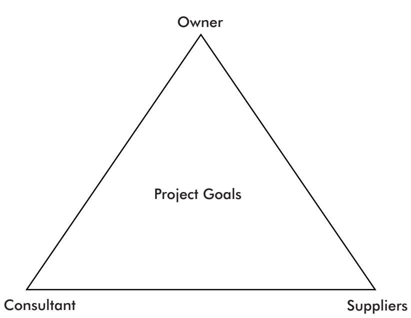

Figure 2 — A team approach.

The specification must be crafted to the project's unique needs, including site conditions, production expectations, company culture, service support and the equipment's long-term value. If components are lower in cost and of a proven technology **(Figure 3 Point A)**, a simpler specification process, utilizing reputable brands and catalog standard products, should result in the appropriate components, and provide the lowest operating cost. But if components are of high cost and critical importance **(Figure 3 Point B)**, a more extensive specification is necessary.

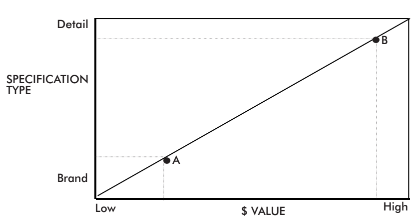

Figure 3 — Specification Type versus Equipment Value

SPECIFICATION DEVELOPMENT

Specifications are drawn upon the cumulative experience of a company's staff or a consulting engineering firm. Reviewing existing specifications, benchmarking similar installations and investigating component options with suppliers will result in the best possible specification for the application at hand.

A specification's objective is to define the expected level of drive system performance. This expectation should be clearly identified in order to provide equipment suppliers with the proper direction for component recommendations. To obtain equivalent proposals from potential suppliers, the specification should be

Service Factors

Nature of Application	Duty Cycle		
	Conveyor Loading	Less than 10 hrs/day	Greater than 10 hrs/day
Standard	Uniform Heavy Duty Severe	1.25 1.25 1.75	1.25 1.50 2.00
Critical	Uniform Heavy Duty Severe	1.50 1.50 2.00	1.50 1.75 2.25

Figure 4 — This chart identifies typical service factors based on the nature of the application, conveyor loading parameters and the conveyor's duty cycle.

detailed, allowing minimal interpretation. Specifications, though, should invite alternatives, providing manufacturers the latitude to offer designs that are superior and more total cost-effective than those specified.

The general specification defines the overall project requirements. Elements to detail include: project scope and schedule; site location/conditions; terminology definitions; system description; design standards; electrical/mechanical interfaces; pricing; brand preferences; terms and conditions; non-inclusions or items supplied by the buyer; quality assurance/testing requirements; references; and project and bid submittal processes.

GEAR DRIVE SPECIFICATIONS

The gear drive is a precision component that relies on solid design, quality components and precise assembly to achieve a reliable operating system. Proper gear drive application requires a selection based on many operating parameters, including input power, load demand, external loads, duty cycle, environment, system accessories and facility needs.

Gear drive selection is then made based on a service factor that accounts for the non-uniformity of torque by the driving and driven machines. For detailed specifications, gear bending strength rating, gear pitting resistance rating, bearing L10/L50 life and specific feature considerations must be considered. Typical service factors for most conveyors are 1.25 uniformly loaded, 1.5 heavy-duty, and 2.0 severe duty, all with a reduction of 0.25 for service less than 10 hours per day. **(Figure 4)**

Specifications that need to be identified include:

- gear drive location
- input (motor)/output (head shaft) rpm and speed range (if variable)
- motor, load and lift power, acceleration/speed control method
- duty cycle, hours per day, days per year
- service factor
- rating standard for a complete gear drive AGMA 6010E88 or ISO TR13593 (DIN 3990 applies to gearing only)
- uni-directional or bi-directional loads
- multiple drive loadsharing, starting sequence
- sound levels (if applicable)
- accessories and options

The best determinant of equipment supply is a successful relationship with a supplier who fully understands the needs of your company, project and facilities. However, in order to compare equipment options on an equal basis, common design and selection criteria need to be established.

A simple specification, quoting to a specific AGMA (American Gear Manufacturers Association) or ISO (International Standards Association) standard and service factor, will provide comparable bids, provided the suppliers are honest in their proposals. Simply stating "rated to AGMA or ISO standards" will not do! A specific standard number must be referenced to ensure an equal comparison.

In some situations, more comprehensive specification criteria will be necessary to assure that the equipment will meet the technical requirements of the project. Specific specification criteria, as outlined in this article, will produce a more rigorous comparison of conveyor drive components, ensuring a gear drive is selected that proves dependable in achieving planned production goals.

CONFIGURATION

The configuration **(Figure 5)** details the required mounting and general physical layout for the conveyor drive installation. Space limitations, structural costs or maintenance needs may dictate the need for a particular drive configuration.

Figure 5 — Examples of different drive configurations

Specifications that need to be identified include:

- parallel, right-angle or concentric shafts
- foot or shaft mounted assembly
- hand or assembly, consider drive commonality goals
- direct connected or belt/chain connected
- motor type (NEMA/IEC, foot or flange mounted), frame size and weight

HOUSING

The gear drive's housing material and rigidity are critical to obtaining high mesh accuracy or full pitch line contact. The housing supports the gearing and, depending upon its specification, provides additional application benefits. For example, a fabricated/cast steel housing provides superior impact resistance, while cast iron provides better noise reduction and vibration dampening.

Specifications that need to be identified include:

- fabricated/cast steel or cast iron housing material
- sufficient housing rigidity that is commensurate with gear quality numbers to assure proper contact under a full load
- housing split orientation (horizontal/vertical) or easily serviceable construction
- blind drilled and tapped fastener holes to eliminate the potential for oil leakage
- gear/internal component inspection capabilities
- drive/motor bases, made from stress relieved fabricated steel with machined mounting surfaces, to accept all system components; base should be designed to withstand starting/stopping loads and load moments, and feature motor and accessory adjustment screws
- with shaft mounted drives, specify a torque arm that properly anchors the drive and permits free movement without binding
- stainless steel identification tags mechanically attached to the housing

GEARING

Gearing is the heart of the gear drive. It must be designed to work as a system with the shafting, bearings and housing to provide high mesh accuracy under dynamic loading conditions. Many of today's drive trains are computer-modeled to ensure accuracy and efficiency.

For more comprehensive specifications, a service factor on bending strength and pitting resistance should be included. A service factor accounts for the non-uniformity of torque by the driving and driven machines. Bending strength indicates the load a tooth can carry without a bending fatigue failure. **(Figure 6)** Pitting resistance is the load a tooth can carry without damaging the profile from surface pitting. **(Figure 7)**

Bending Strength/Motor Power Ratio

Nature of Application	Duty Cycle	
	Less than 10 hrs/day	Greater than 10 hrs/day
Standard	1.50	1.75

Figure 6 — Bending strength is the load a tooth can carry without a bending fatigue failure.

Pitting Resistance/Motor Power Ratio

Nature of Application	Duty Cycle	
	Less than 10 hrs/day	Greater than 10 hrs/day
Standard	1.25	1.50
Critical	1.50	1.75

Figure 7 — Pitting resistance indicates the load a tooth can carry without damaging the profile from surface pitting.

Gear quality numbers should also be provided in the bid for reference. A quality number of AGMA 10-12 is standard for modern case carburized and finished ground gears. To compare AGMA quality numbers to DIN quality numbers, subtract the AGMA number from 17 to obtain an equivalent DIN quality number.

Specifications that need to be identified include:

- single helical or spiral bevel gear types
- case carburized and finish ground gear design
- minimum gear class of 10 AGMA (7 DIN)
- efficiency minimum of 99 percent per mesh helical, 98.5 percent per mesh spiral bevel
- 200 percent momentary overload capacity
- bending strength and pitting resistance service factors on detailed specifications

For critical systems, typically 1,000 HP (750 kW) and larger, full details for each reduction stage and component rating summaries should be outlined. **(Figure 8)**

SHAFTING

Shafting is rated on its ability to accommodate bending and torsional loads. Shaft loads result from external forces due to misalignment, belt drives, chain drives, flywheels, brakes or other accessories. Depending upon customer preference, inch and metric shaft extensions are available from most manufacturers.

Specifications that need to be identified include:

- inch or metric design standard
- unit assembly arrangement
- required extensions (solid shaft, hollow bore diameter, tapered bushing or shrink disk connection)
- special requirements

BEARINGS

Anti-friction bearings are typically chosen for most conveyor drive applications. Tapered, spherical or straight roller bearings are the common types used.

To specify bearing performance, a bearing life expectancy measurement, called bearing L10, is utilized. Bearing L10 life represents the point at which 10 percent of a group of identical bearings will experience a spall of 0.01 square inches. It is the life expectancy associated with 90 percent reliability. Most bearing manufacturers employ a more detailed bearing rating method that considers actual operating conditions, such as operating temperature, lubricant type, nature of filtration or contamination, bearing material,

Rating Summary Data Sheets Each Reduction

Shaft	Pinion	Gear
Radial load, at drive side bearing (lb)		
At non-drive side bearing (lb)		
Thrust (lb)		
Bearing number, drive side		
Non-drive side		
Thrust		
Gearing		
Transverse diametrical pitch		
Helix angle		
Operating pressure angle		
Number of teeth		
Pitch diameter		
Hardness BHN		
Face width		
AGMA quality number		
AGMA Strength Coefficients		
Kv		
Ko		
J		
Km		
Ks		
Kl		
Kt		
Kr		
Sat		
AGMA Durability Coefficients		
Cv		
Co		
I		
Cm		
Cs		
Cf		
Cp		
Cl		
Ch		
Ct		
Cr		
Sac		
AGMA gear set quality number		
Gear set bending strength rating		
Gear set bending strength service factor		
Gear set pitting resistance rating (AGMA)		
Gear set pitting resistance service factor		

$$\text{Service factor} = \frac{\text{Gear Rating (hp)}}{\text{Motor (kw)}}$$

Figure 8 — This worksheet details the information to be outlined for critical systems 1,000 HP (750 kW) and larger.

geometry and load zone. A proper specification defines unity (1.0) bearing rating life adjustment factors or uniform criteria for a detailed analysis by all suppliers. **(Figure 9)**

Bearing L10 Recommendations

Nature of Application	Duty Cycle	
	Less than 10 hrs/day	Greater than 10 hrs/day
Standard	10,000	20,000
Critical	25,000	50,000

Figure 9 — Bearing L10 life helps specify the most appropriate bearing life for a particular application.

Specifying an excessively high L10 can have an adverse effect on bearing performance, resulting in bearing loads so light that the rollers skid, rather than roll as intended. Bearing failures are associated with contamination, poor lubrication, overload, excessive vibration and improper bearing load zone or settings. A high L10 value does little to prevent these failures.

Using the correct oil and operating at lower temperatures by installing additional cooling and filtration can economically extend bearing life and performance.

Specifications that need to be identified include:

- readily available commercial roller bearings; spherical, cylindrical or tapered roller type
- bearing L10 life based on unity (1.0) factors for temperature and oil cleanliness, or uniform criteris for detailed analysis.

SEALING

Properly sealed gear drives avoid repair expenditures and facility downtime. Any interfaces where oil could leak out or contaminants could permeate the gear drive must be sealed. The use of sealants and gaskets are proven methods for sealing structural components. Critical interfaces to seal include housing joints, retainer/seal cage joints, breathers, piping and shaft seals.

Most industrial gear drives are equipped with a radial lip, labyrinth or face seals. The integrity of a radial lip seal system depends on the successful operation of all components: plunge ground shaft

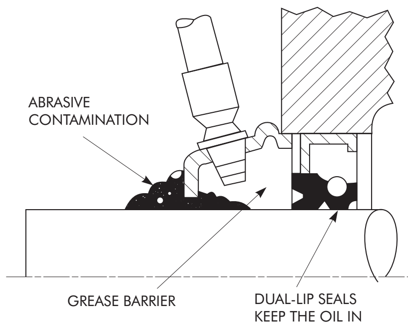

Figure 10 — Viton™ lip seals offer superior resistance to high temperatures and chemical attack. This illustrates a lip seal with a grease purge feature.

journal, lip seal, lubricant, and seal housing bore. **(Figure 10)** Lip seals are usually Nitrile material and they are also available in premium Viton™, offering superior resistance to high temperature and chemical attack. For larger drive systems provisions should be made to replace the seals without moving the major drive components.

Labyrinth and bush seals are premium non-contact sealing systems that last indefinitely. **(Figure 11)** A grease purgeable

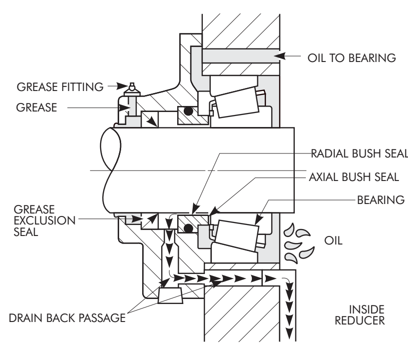

Figure 11 — Labyrinth and bush seals last indefinitely.

cavity or contaminant exclusion system is recommended for severe environments.

Specifications that need to be identified include:

- breather filtration to 20 microns
- contact seals (Nitrile or Viton) with grease purged barrier seals
- optional labyrinth seals with contaminant exclusion system for larger drives

LUBRICATION

Lubrication is crucial to long life and reliability. Viscosity is the single most important property of lubricating oils. For a gear drive to function properly, oil viscosity must be kept within certain limits.

An oil should be selected with a pour point of 10º F (5º C) below the minimum system starting temperature, with a maximum viscosity of 15,000 cST (70,000 SUS). If a drive is equipped with an oil pump, the maximum viscosity should not exceed 1,725 cST (8,000 SUS). Minimum viscosity should not be less than 33 cST (155 SUS) at maximum operating temperature. The oil cannot be so thick that it will not flow and yet not too thin that the gear teeth are not protected by a lubricant film.

The gear drive manufacturer should specify a lubrication method and lubricant appropriate for site conditions. Depending upon the drive size and cooling requirements, lubrication can either be dip/splash and gravity fed or pressure fed.

Specifications that need to be identified include:

- drain valve for oil changes
- oil dipstick or sight gauge to check oil level and quality
- dip lubrication with continuous flow or pressure lubrication for larger systems
- dual 10-20 micron filters for pressure lubed systems

COOLING

Conveyor drive cooling methods include natural cooling, shaft fan(s), electric fan(s) and heat exchanger(s). **(Figure 12)**

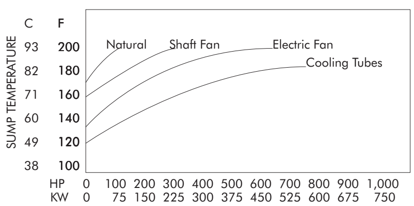

Figure 12 — Drive system size and ambient conditions influence the appropriate cooling method.

With today's compact drives, natural cooling is practical only with the lower power range of conveyor drives. Not specifying auxiliary cooling results in a substantially oversized drive or the use of through hardened gearing.

Shaft and electric fans offer a simple and effective means of cooling for many requirements. For very large gear drives, a pump and air-to-oil heat exchanger, combined with an oil filtration system, provides a quality cooling system. If a motor or pump is employed, monitoring is strongly recommended to provide warning and shutdown prior to a catastrophic failure.

Thermal rating, the maximum power a gear drive can continuously transmit without exceeding a specified maximum oil temperature, is an important consideration when selecting a cooling method. An acceptable mean oil temperature is 160º F (71º C). Operating temperatures above 200º F (93º C) will significantly reduce lubricant, contact seal and drive life. Site conditions, such as altitude and ambient air temperature, are also important to the thermal rating calculation.

Specifications that need to be identified include:

- site elevation and ambient conditions (high/low temperatures)
- minimum start up temperature
- average gear drive operating temperature of 160º F (71º C)

CONNECTIONS

Gear drive connections for conveyors are generally shaft couplings, v-belt drives and/or hollow shaft locking devices used for shaft mounting.

The four primary types of couplings are grid, gear, disc and elastomer. **(Figure 13)** Grid or elastomer types are appropriate selections for

Figure 13 — The four primary types of couplings are (top left) disc, elastomer, grid and gear.

high-speed connections, while grid couplings are generally the best all-around selection for low-speed connections.

V-belt and synchronous belt drives are used extensively on parallel-shaft mounted drives in powers up to 200 HP (150 kW) or for space-restricted installations.

Shaft mounted connections **(Figure 14)** include flanged low-speed couplings, hollow low-speed shafts

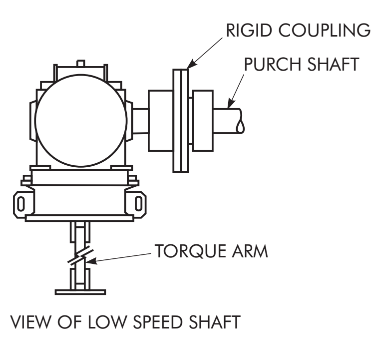

Figure 14 — A shaft mounted right angle drive.

with shrink discs or tapered bushings. For large shaft mounted conveyor drives, a flanged low-speed coupling is preferred, due to its ease of mounting and ability to use standard gear drives.

Specifications that need to be identified include:

- coupling type (grid, gear, elastomer, disc), lubricated or non-lubricated, torsionally rigid or torsionally soft
- shaft diameters/keys
- service factor equal to gear drive
- clearance with set screw(s) or interference coupling hub fits
- shaft coupling face key required for high-speed backstop-equipped applications
- hub puller holes or hydraulic removal required on larger couplings
- guarding that is compliant with OSHA 1910.219 (Standard – 29CFR) Mechanical Power Transmission Apparatus and in conformance with ANSI and ASME B20.16-1992 Safety Standards for Conveyors and Related Equipment and B15.16-1998 Safety Standards for Mechanical Power Transmission Apparatus

PAINT

For most conveyor requirements, the manufacturer's standard paint provides adequate protection against corrosion. If a gear drive will be exposed to a corrosive environment and/or chemical attack, a premium paint should be specified.

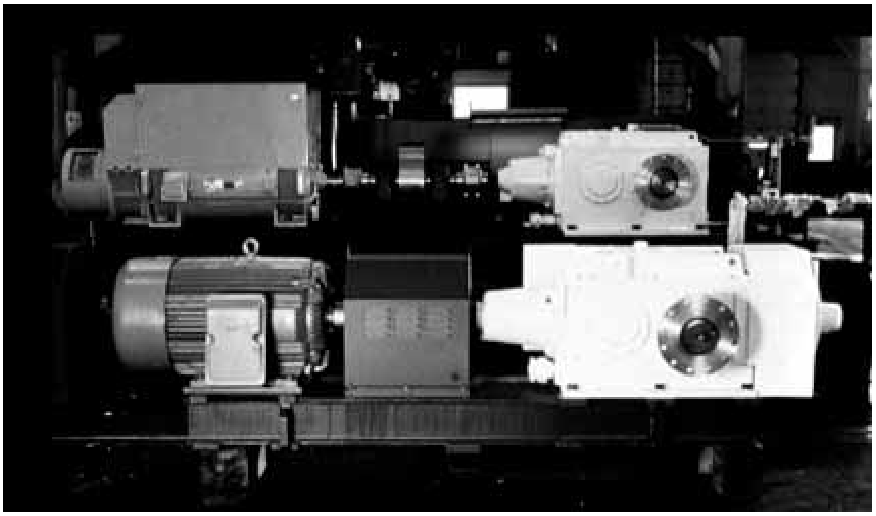

Figure 15 — Drives exposed to direct sunlight will run cooler with a white reflective paint.r

(Figure 15)

Specifications that need to be identified include:

- type of paint finish: one coat phenolic alkyd primer with finish coat alkyd enamel (standard paint) or two coat epoxy paint with abrasive blast for corrosive environments
- color, if required, to match uniform color or to reflect direct sunlight (white)
- if standard paint will be top-coated at the job site, check for compatibility

ACCESSORIES AND OPTIONS

In addition to the gear drive assembly, there are accessories and options that can be integrated to add functionality and increase performance. They include:

- soft start/controls (fluid, electronic, variable)
- backstops (internal, external, low speed)
- brakes (holding, dynamic)
- flywheels (shaft mounted, jack shaft mounted)
- inching drives (manual, automatic)
- heaters (immersion, recirculating)
- monitoring devices (temperature, vibration, speed, pressure/flow)

REVIEWING SPECIFICATION PROPOSALS

After the equipment proposals have been received, a thorough review of costs, conformance, alternatives and suppliers must be completed. It is recommended that the proposal be reviewed in detail with those suppliers under serious consideration. Information that is necessary during this review process includes:

- pricing/initial costs
- data sheets
- operating costs
- warranties
- manufacturer's product specifications
- testing (no load, full load), inspection (assembly, test, commissioning) and verification (documentation)
- commonality/spares costs
- service information and support network availability (local representation, factory support, regional inventory, Internet)
- qualifications (ISO 9001, etc.)
- references

After specification evaluation, a contract is awarded. The chosen supplier must adhere to the negotiated contract. Once the equipment is installed and commissioned, ongoing monitoring of operational performance should be made to determine if the owners' requirements were successfully met.

CONCLUSION

A specification is the process of accumulating and applying actual experience to develop guidelines and requirements for new equipment procurement. The gear drive specification considerations for conveyors outlined above will guide facility personnel, consultants and equipment suppliers in the proper and dependable compilation of conveyor drive system components to meet a project's productivity requirements and goals.

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