# The Drive for Today - And Many Tomorrows

*A Walker Process Equipment position paper relating to*
*Drives from a historical, comparative and upgrade perspective.*

*by*

Arthur C. Schlicht

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**Walker Process Equipment**
Division of McNish Corporation
840 North Russell Avenue
Aurora, IL 60506

PHONE: (630) 892-7921
FAX: (630) 892-7951

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## HISTORICAL

Walker Process Equipment, a Division of McNish Corporation, began as a supplier of equipment to the Water and Wastewater market in 1946. Supply of circular clarifier mechanisms has always been a major line of offerings, as it continues to be today. For that reason, we take seriously the highest design and quality parameters of the prime element of those equipment items, the spur or worm gear drive.

Worm gearing has been designed and produced in the Walker Engineering and Manufacturing facilities since the very beginning. Early versions of pier-supported collectors were driven by worm gear drives, which were made, as today, in pitch diameters of 14", 28" and 41". Later, a 16" gear was added to the line. Today, worm gear drives are used exclusively for driving bridge-supported collectors and thickeners.

Spur gear drives were originally designed and manufactured in the late 1950's. It is important to note that Walker has had its own manufacturing facility since 1950.

Spur gear drives are used with pier-supported collectors and thickeners, and are made in pitch diameters of 28", 42", 60", 80" and 100". The latter three sizes are available in both single pinion and double pinion versions. Torque capacities are available up to 475,000 ft-lb.

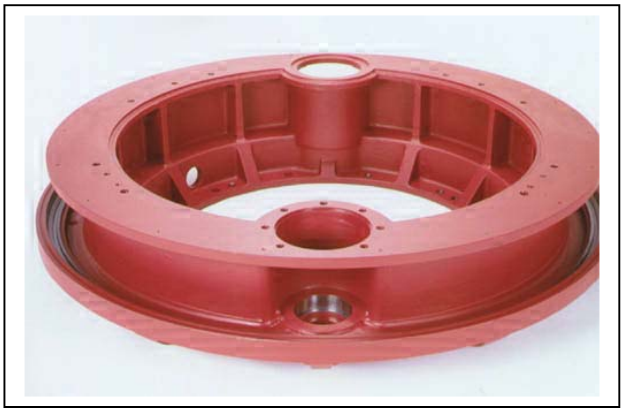
Early torque ratings were based on the Lewis Beam formula, a criteria that considered tooth strength only. In the 1970's, specifications began to appear requiring that spur gear ratings be based upon AGMA standards, at that time AGMA 210 and 220 for spur gearing, and AGMA 440 for worm gearing. AGMA 210 brought durability into the rating equation.

Since that time, AGMA 210 and 220 were combined into new standard AGMA 218, and later into ANSI/AGMA 2001. AGMA 440 evolved into ANSI/AGMA 6034. Throughout the evolution of these standards, Walker Process gear drives have consistently demonstrated over 35 years of life. Only suppliers such as ourselves who have kept current with, and reacted to, the changing standards can truly state that their gear drives are "Designed in full *conformance* with ANSI/AGMA standards."

Beware of suppliers who promote that they "Design in *accordance* with ANSI/AGMA criteria". They should be viewed with a jaundiced eye, and questioned regarding their actual design practices.

This series of standards revisions, with more stringent parameters, mandated that gear drives be either derated or upgraded. In order to gain full compliance with ANSI/AGMA criteria, in the 1990's Walker Process began a program of upgrading its entire line of drives, including materials, quality and production machinery, under the guidance and input of members of AGMA gear committees. Today our gearing is a leader in this industry. This paper discusses in detail many of the elements that make this claim a reality.

## MATERIALS



**HOUSINGS -** Traditional, long-term suppliers, including Walker Process, have employed cast iron as the material of choice. This choice is not only better but also exemplifies a commitment to this industry, inasmuch as there has been an investment of patterns and production machinery that a newcomer generally chooses to bypass. These new entries into the market will claim fabricated steel housing as being better, but in reality they have taken a lower-cost approach with no increase in utility or quality. At least two companies, one a clarifier manufacturer, and one a supplier of gears to the replacement market and to collector manufacturers without gears of their own, have taken this road.

Cast iron has many advantages when compared to fabricated steel:

A. Varying section thicknesses apply strength where it is needed. Properly designed, cast iron provides exceptional rigidity and structural support.

B. Due to the differences in both process and material, cast iron has superior dampening properties to that of fabricated steel, reducing the effects of vibration.

C. Cast iron has a long-standing acceptance in this industry for corrosion-resistance. One example is its use for sewer pipes, with little or no requirement for coatings or other means of corrosion protection. Low carbon or alloy steel would not be considered for sewer pipe because it corrodes readily.

D. The process of pouring a casting, cooling, stress relieving and testing for the appropriate properties in accordance with ASTM standards and specifications, assures that from that point forward, the casting is dimensionally stable. The manufacturing process requires only machining to tolerance dimension, which is not true with fabricated steel.

E. Cast iron places no dependency on weld quality or pre- or post-weld heat treatment.

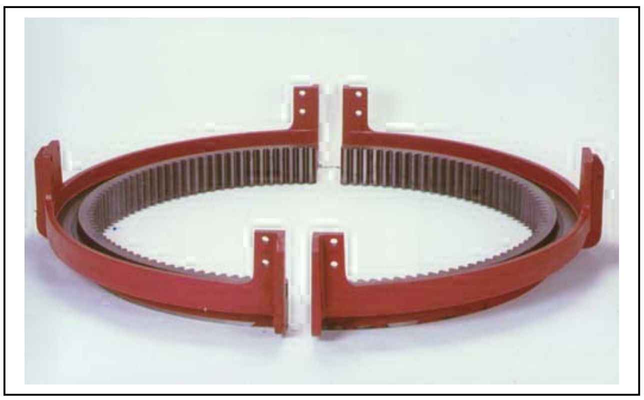
The stress relieved cast iron housing has superior geometry for rigidity and support, and superior dampening and corrosion-resisting properties. The significantly higher capital investment in patterns is justified by the resulting product quality achieved. The specifier should demand this quality.

As indicated earlier, it is common knowledge that cast iron has a greater corrosion resistance than steel. Those vendors who offer fabricated steel housings rely on their coating systems to relieve them of this disadvantage. If indeed the drive is expected to be in service for 20 years or longer, it is doubtful that any coating will remain integral. It is also becoming more common for clarifiers to be covered, many times without satisfactory exhaust systems, resulting in the confinement of moist, corrosive constituents. In time the coating system will fail, exposing the base material. Best to have a material which itself exhibits superior corrosion resistance.

Additionally, it must also be pointed out that the Walker Process housing features a lower pinion bearing support that is integrally cast as part of the housing to provide a rigid mounting with full 360 degree support for the bearing.

**SPUR GEAR RING -** These are cast of ductile iron, quenched and tempered, conforming to both ASTM A536 and ANSI/AGMA 2001. For general application, we have chosen grade 80-55-06 with a microstructure of fine tempered pearlite. This material has a minimum base hardness of 220 BHN, and, *after* heat treatment, the teeth are cut to a minimum AGMA quality 6 in conformance with ANSI/AGMA 2000. This combination of material, hardness and quality provides torque ratings in conformance with ANSI/AGMA standards. For applications requiring higher torque ratings, the ring gear can be supplied in grade 120-90-02 with a minimum base hardness of 270 BHN.

One supplier of steel gears admits that the spur gear ring they supply is manufactured to AGMA quality 7 *prior to* heat treatment, but that the finished product reverts to a quality 5 or 6.



It is important to note that ANSI/AGMA 2001, Section 16, Tables 5 and 6, requires that ductile iron materials in grades 80-55-06 and higher to be austenitized, quenched in a suitable media, and tempered to the required hardness to attain ratings in accordance with this standard.
AS-CAST DUCTILE IRON MATERIAL CANNOT CLAIM ANSI/AGMA 2001 RATINGS.

A most desirable and useful feature of the Walker drive is the split spur gear ring. This feature permits removal of the ring gear to gain access to the balls and races without removal of the bridge, which is especially important if the bridge structure is large and cumbersome. Some competitors resist splitting the ring gear and, in fact, promote specifications that would penalize, without merit, the split ring joint. In the case of suppliers who buy components, this promotion is due to the fact that a split ring is simply not commercially available. Surely, considerations of ease of maintenance and inspection should prevail.

**PINIONS** - The pinion is manufactured of AISI 4150, ANSI/AGMA 2001 grade 2 steel, heat-treated to a minimum through hardness of 321 BHN hardness. When specifications require higher torque ratings, surface hardness may be increased to as high as 561 BHN. Normal production assures AGMA class 8 quality. There exist three (3) distinct features which do not occur in tandem on any competitor's drive and which offer these desirable advantages:

The pinion and shaft are of single piece construction, in lieu of the pinion being keyed to the shaft as is offered in some competitive units. This assures a unitary and lasting component, free of fretting wear or corrosion found commonly in shell & shaft pinions.

The pinion shaft is straddle-mounted between roller bearings, rather than using an overhung load design.

Attendant with the straddle mounting of the pinion shaft is the feature of Low Aspect Ratio. Aspect ratio is a slenderness ratio defined, by AGMA, as the face width divided by the pitch diameter of the pinion; the lower the aspect ratio, the stiffer the pinion, and the higher it can be rated in conformance with AGMA criteria.

The subject of aspect ratio is new to ANSI/AGMA standard 2001. Specifically it relates the drive rating to the aspect ratio; higher aspect ratio, which by definition results in a weaker, less rigid pinion with resulting mesh misalignment, demands downrating the torque capacity. Walker Process drives have among the lowest, if not the lowest, aspect ratios in this industry.

At least one competitor promotes a deep-faced pinion, a smaller spur gear pitch diameter, and a specification requiring a minimum "area" of spur gear, defined as the pitch diameter x the face depth x pi. (Obviously, a similar pitch diameter gear, with a shallower face width and, therefore a desirable lower aspect ratio, will not match this specified "area".) Not only is there no AGMA validity to this scheme, chances are that no diminishment of torque capacity is being taken for the higher aspect ratio.

**WORM AND WORM GEAR** - Our worm and worm shaft are of one-piece construction, specifically NOT a shell worm, as is provided by some competitors, which is susceptible to fretting wear and corrosion. The material we selected is AISI 8620 alloy steel, carburized, hardened and ground to case hardness of 58 Rc. While there is no current ANSI/AGMA standard that defines accuracy classification, there is one which is to be issued in the near future. When issued, our worm set will qualify for an ISO 10 rating.

The worm gear is centrifugally cast high strength manganese bronze, conforming to ASTM B271 and ANSI/AGMA 2004, with a hardness of 200 BHN minimum. The worm gear is mounted on a cast iron hub that is securely keyed to the pinion shaft.

The intermediate worm gear housing is cast iron, flange-mounted to the cast iron spur gear housing with a full 360 degree bearing area. At least one competitive brand does NOT provide full 360 degree mounting of the worm gear housing and, in fact, "sandwiches" a steel spur gear housing top plate between the two castings, which diminishes registry of the two housings.

One competitor has attacked the traditional use of a worm gear intermediate reduction, opting for a planetary system. They claim a much higher efficiency, (95%), and indicate the worm gear efficiency is 40-50%. (In reality, the typical worm gear efficiency is 55-60%.)

Interestingly, the supplier of this planetary drive does not publish efficiency data for clarifier drives or even mention it in their literature, probably due to the fact that calculations reveal an overall efficiency of a typical triple reduction, grease-lubricated cycloidal drive selection to be approximately 46%!

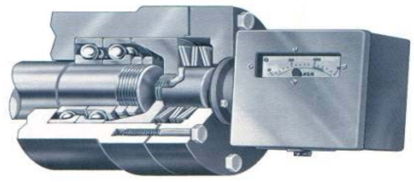
Further, this planetary system requires the use of grease lubrication, not oil. The gear requires monthly regreasing as opposed to semi-annual change of oil. Additionally, the supplier's own catalog describes a very meticulous relubrication procedure, warning that too little grease will result in overheating and ultimate damage of the eccentric bearing. Conversely, too much grease will result in agitation heating of the grease, resulting in further loss of efficiency. Moreover, a complete repacking of the gear case must be carried out every two to three years, requiring total disassembly of the unit.

## TORQUE LIMITING DEVICE

The torque-limiting device, known as the Torque Indicator, is mounted on the housing at the end of the worm shaft of the driving unit. The end thrust of the worm shaft is made to operate against a series of springs in the alarm housing, compressing them an amount in proportion to the load that is required to operate the machine, causing movement in the indicator mechanism. This movement is transmitted to a dial indicator inside the housing cover. Two switches are mounted on the thrust shaft and are arranged so as to first sound an alarm and then to stop the motor when preset output torque values are reached.

For added protection, a shear pin coupling is normally added in the drive assembly. The shear pin connects the non-keyed driven sprocket with a keyed shear pin coupling. If the torque transmitted by the chain pull on the driven sprocket exceeds a predetermined limit (typically 180% of the continuous torque rating), the shear pin will experience failure, and no longer transmit force to the drive sprocket, thus stopping rotation of the drive output.

The shear pin overload can be equipped with a limit switch that will activate an alarm upon breakage of the shear pin.



**LUBRICATION -** Both the spur gear and worm gear cavities are filled to operating level with oil. In the case of the spur gear, the lower portions of the teeth are immersed in oil, and the high pressure meshing action of the gear teeth pumps the oil upward along the full flanks of the teeth, to the top of the teeth, from which it cascades downward over the adjacent teeth. This oil cascade forms a lubricant film on the finely machined tooth flanks. In addition to many years of successful experience, many authorities in the gear industry back this type of lubrication practice.

The subject of lubrication is not complete without a review of condensate removal. Condensation will occur whenever the temperature within the drive falls below the dew point. Water and wastewater clarifier drives operate in an environment which has greater than normal humidity and temperature variations, ideal for the formation of condensate. Thus, condensate removal should be an important consideration for all drive manufacturers, whether the drives be oil or grease lubricated, to prevent the contamination of the lubricant and corrosion of the gears and bearings.

Walker Process has developed what may be the most effective condensate removal system in the industry. Condensate is collected at multiple low points in the worm and spur gear housing oil reservoirs. The *majority* of the condensate is collected and removed at the housing condensate drains, preventing gravitation of condensate to the lowest point in the housing, the pinion sump.

Special attention has been paid to the removal of condensate from the region of the pinion lower bearing. While some manufacturers claim to prevent passage of condensate through the lower bearing, no one has found a way to defy gravity. Walker has taken the course of moving the condensate through the bearing region as quickly as possible. The condensate is collected in a specially designed pocket, well below the bearing, minimizing any contact with the bearing. The pocket design, unlike many others, provides full support to the bearing outer race, which is vital to the bearing function and life.

All condensate removal systems rely, however, on the human factor. A well-managed maintenance program must be in force to assure removal of the condensate collected as above described. For those installations which might benefit from continuous condensate monitoring and removal, Walker Process has a sentinel system which automatically and continuously drains condensate as it settles to the collection points of the spur gear housing, from which it can be delivered to collection containers or drainage piping for disposal.

**MAIN BEARING -** The subject of the main bearing has become the most controversial subject relative to competitive promotions of gears. The traditional clarifier drive used in the U.S. has been the replaceable race insert, bearing ball design, which has been promoted by Walker Process.

There are two (2) vertical and two (2) horizontal race inserts of hardened alloy steel, heat treated to a minimum hardness of 43 Rc to resist fatigue cracking, and ground flat to parent metal to eliminate possible imperfections. The bearing balls are 1-1/2" dia. (1-1/4" dia. in 28" gear) AISI E52100 Grade 50 chrome alloy steel. This main bearing arrangement features the following:

A. An L10 design life of 20 years or more based on combined thrust and radial loads. Thrust loads are well identified. Radial loads may not be recognized or considered by others but can be significant. L10 design life should include both.

B. Utilizes replaceable race inserts that prevent wear on the main gear casting. Because of the combination of the split gear construction and the one-piece cast iron housing, the field replacement of race inserts and bearing balls can be accomplished without removing the pinion driver assembly.

C. Does not lock forces into a contained structure, thereby reducing the danger of damaging the gear from icing or excessive runaway torsional forces. Because the bearing races allow the bearing ball to seat itself as loading requires, lowered Hertzian stress occurs at the point of contact for both the ball and the race.

The controversial element that has crept into the competitive market concerns the promotion of a "gear assembler" towards a so-called "precision bearing". This term has also become convoluted into referencing the entire gear drive as a "precision *gear"*.

The "precision bearing" that is being promoted is a four-point contact Gothic arch race bearing with an integral gear, produced by either of two bearing manufacturers. It was originally developed for high overturning loads with *little or no radial loads*, such as cranes. A key element of this promotion is that the contoured raceways are 30% harder than other's race inserts, resulting in "better wearability". In reality, since the Gothic arch radius does not exactly match the curvature of the ball, which produces high surface stresses, the contoured raceway *REQUIRES* an increased hardness and very a fine surface finish to support the loading requirements. This bearing also requires bearing ball spacers, which reduces the number of balls and, therefore, increases the loading per ball.

On the other hand, Walker Process' race inserts, although not as hard, have planned deformation such that the race will exactly conform to the ball, resulting in low interface stresses; the bearing ball contact pattern becomes the ideal ellipse. A full complement of bearing balls further reduces the stresses.

The word "precision" should not be taken as an ANSI, AGMA or ABMA definitive term, nor should it be understood to infer that their drive elements have higher AGMA accuracy classification than does the Walker drive. As discussed earlier, a case can be made for our drive being of higher "precision" *as defined by AGMA* than is theirs. On a *comparative* basis, the Walker drive is more deserving than theirs of being referred to as a "Precision drive with replaceable race inserts".

## COMPETITION COMPARISON

On the last page is a comparison of meaningful features of Walker's drive to those offered by selected competitors.

## ADDITIONAL, MORE DETAILED, INFORMATIONAL PAPERS AVAILABLE

Much more detailed information is available in the following papers, by request:

***"A Brief History of the Walker Process Equipment Internal Spur Gear Drive"***, (undated); Provides further detail of the history of the Walker Process drives.

***"Walker Process Turntable Bearing is Not Just Another Lazy Susan!"***, March 2002

***"Automatic Condensate Removal System"***, January 2006

***"Comparison Of Clarifier Drives"***, March 2000; Examines the precision, metallurgy and material ratings, as well as corrosion resistance of Walker Process Equipment drives, as compared to other manufacturers.

***"Drive Comparison – Replaceable Wire Races vs. Gothic Arch Combination Gear and Bearings"***, February 2003

***"Four Point Contact Slewing Bearing Lubrication and Maintenance"***, May 2006; Discusses in detail the intricate lubrication procedures necessary for the four point contact bearing.

***"Lubrication of Clarifier Drives – Why Oil is Preferred over Grease"***, July 2001

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# Physical Features Comparison Chart

| Features | Integrated Manufacturers | | | Component Assemblers | |
|---|---|---|---|---|---|
| | Walker Process | Envirex | EIMCO | WesTech | DBS |
| **Cast Iron housings** | Yes | Yes | Yes | No | No |
| One Piece Housings | Yes | Yes | No | No | No |
| Spur Gear Ring Split Ductile Iron? | Yes | Yes | No | No | No |
| Quenched & Tempered? | Yes | Yes | **?** | N/A | N/A |
| | | | | | |
| **Bearings** | | | | | |
| Ball or roller bearings throughout | Yes | Yes | No | Yes | Yes |
| Replaceable race insert main bearing | Yes | Yes | Yes | No | No |
| Full compliment of bearing balls (no spacers) | Yes | Yes | Yes | No | No |
| | | | | | |
| **Pinion** | | | | | |
| One-piece, eliminating keyed connections | Yes | **?** | Yes | No | No |
| Straddle mounted | Yes | Yes | Yes | Yes | No |
| Low Aspect Ratio | Yes | | | **?** | **?** |
| | | | | | |
| **Simplified Worm Gear drive for ease of maintenance** | Yes | Yes | Yes | No | No |
| Full 360 degree contact and support of worm gear housing on main housing | Yes | Yes | No | Yes* | Yes* |
| | | | | | |
| **Worm Shaft** | | | | | |
| Straddle mounted | Yes | Yes | Yes | N/A | N/A |
| One-piece, eliminating keyed connections | Yes | **?** | No | N/A | N/A |
| | | | | | |
| **Lubrication** | | | | | |
| Spur and Worm Gears exclusively oil lubricated | Yes | Yes | Yes | No | No |
| No seals of gaskets located below oil level in main housing. | Yes | Yes | Yes | No | No |
| Positive removal of condensate and contaminates from lower pinion bearing sump. | Yes | Yes | No | **?** | **?** |
| Can drain oil from sumps such that oil is removed prior to opening the gear. | Yes | Yes | Yes | Yes | No |

* No worm Gear, but applies to intermediate housing.