DRIVE COMPARISON

Walker Process Equipment

Replaceable Wire Races

VS

Gothic Arch Combination Gear and Bearings

by

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President

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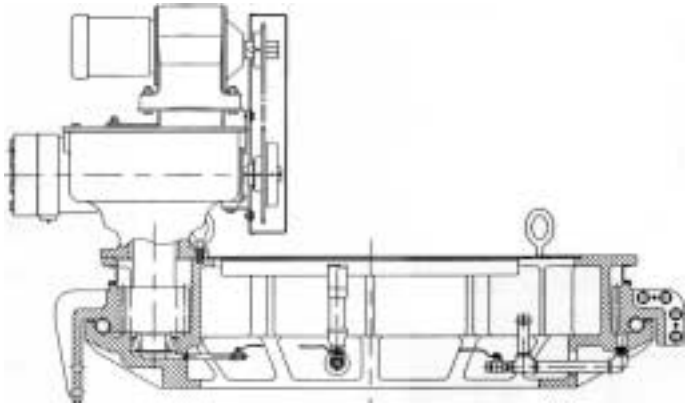
WALKER PROCESS EQUIPMENT
Division of McNish Corporation

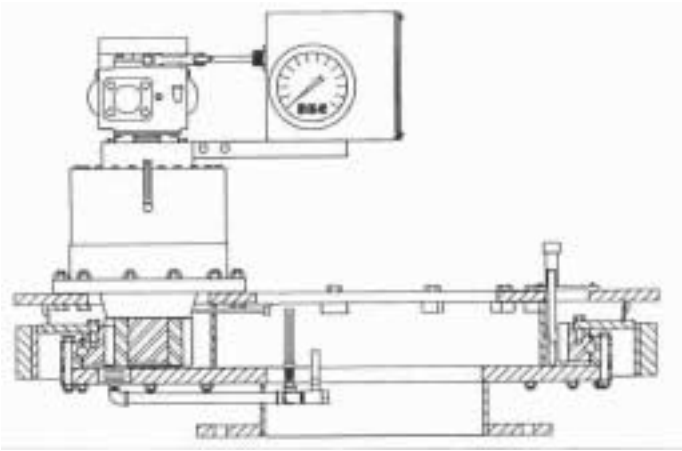
“ENGINEERED SOLUTIONS”

DRIVE ASSEMBLIES

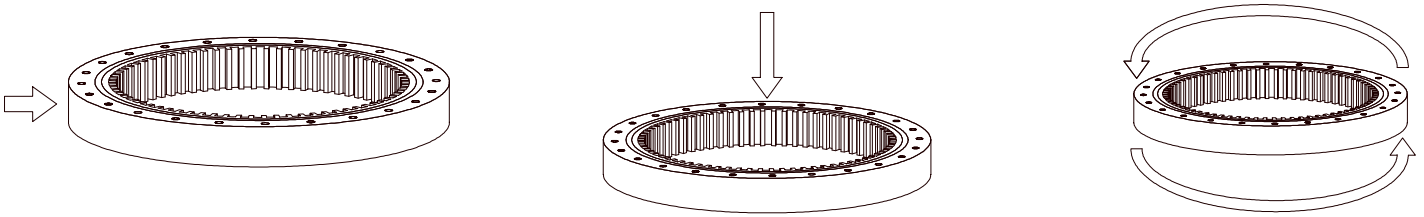
WALKER PROCESS EQUIPMENT
Replaceable Wire Race Drive



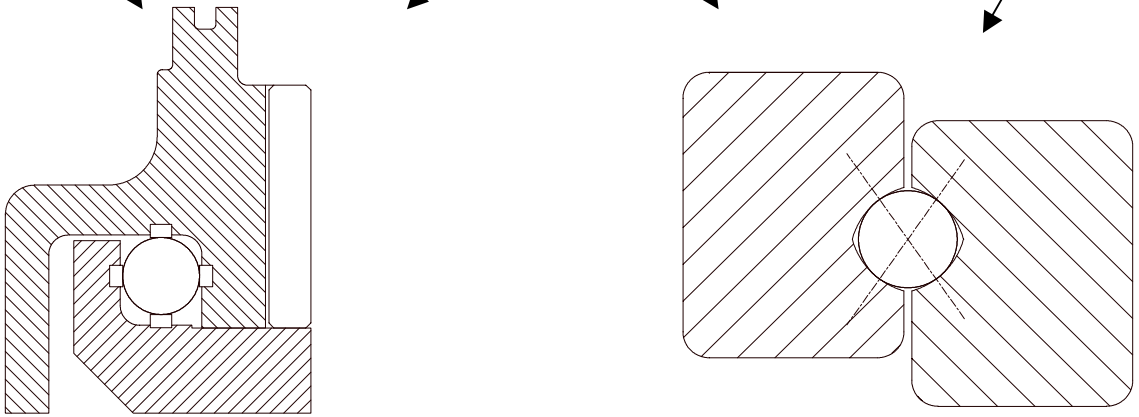
GOTHIC ARCH
A Combination Gear and Bearing Drive



Design Load Considerations



Radial **Thrust** **Overturning**



Replaceable Race **Gothic Arch**

Walker Process Equipment Drives Utilizing Replaceable Wire Races

Specifically designed for the Water and Wastewater Industry requirements of high thrust, high radial loads and continuous operation in the mid 1930's utilizing wire race technology.

Approximately 68 years ago

Gothic Arch Combination Gear & Bearings

Specifically designed for applications with high overturning moments and moderate thrust combined with low radial loads (less than 10% of axial loads previously described)[1] in the mid 1940's. applications included cranes, back hoes, etcetera.

Approximately 58 years ago.

(1) Reference: Kaydon Literature

Technology Improvement Since Original Introduction

Improvements have occurred in:

Metallurgy
Mill Practice
Heat Treating
Accuracy of Manufacturer
Quality Control Procedures
Introduction and development of degassed wire races

Improvements have occurred in:

Metallurgy
Mill Practice
Heat Treating
Accuracy of Manufacturer
Quality Control of Procedures

Summary:

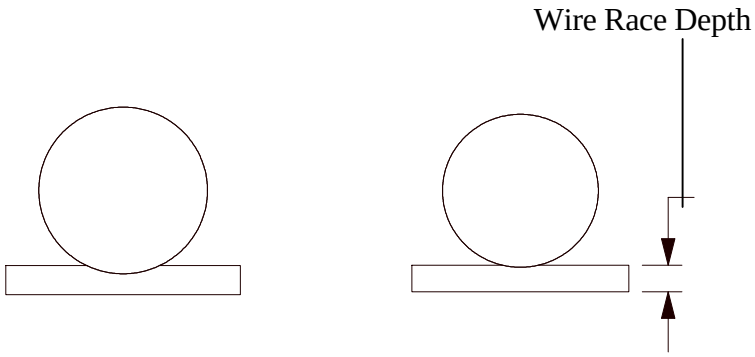
1) Both designs have experienced similar improvements over essentially similar periods of time.

2) The replaceable wire race design is specifically designed for the Water and Wastewater Industry. The Gothic Arch design is specifically designed for high overturning moments, moderate thrust and low radial loads.

COMPARISON OF REPLACEABLE WIRE RACE DESIGN TO GOTHIC ARCH RACEWAYS

Replaceable Wire Races

Wire races are designed for planned deformation to conform to ball radius at the ideal ellipse for a specific load.



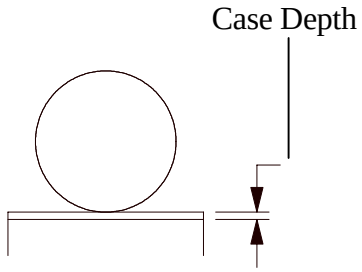
Load A **Load B**

Equilibrium is achieved for individual load conditions providing conformance at optimum stress levels between races and bearing balls such that pitting is not a consideration

Minimum depth of wire race is 0.250" .

Gothic Arch

In order to support high overturning moments the raceway surface is designed to withstand the applied force without deformation creating peak compressive stress at center of contact area.



Design concerns include:

a) Prevention of raceway deformation
b) The ability of the case to resist force without cracking and deforming.

Maximum case depth for 1 ½" bearing balls is .075".

COMPARISON

Replaceable Wire Races	Gothic Arch
The replaceable wire race design permits the use of a full complement of bearing balls as the bearing's balls are able to roll without scuffing.	When radial loads exceed thrust loads less than optimum conditions are created that require more conservative design considerations. 1) The Gothic Arch design with high radial loads does **not** permit the free rolling of the bearing balls. There is an undesirable increase in the friction and sliding action in the ball members. Plastic spacers are required reducing the number of balls for a given diameter by 25% relative to wire race design. 2) The radial bearing capacity of Gothic Arch Combination Gear and Bearing is on average 40% of the thrust bearing capacity
Selection of replaceable wire races allows for changing out raceways and bearing balls where required utilizing the same housing and main gear.	When raceway deteriorates the entire gear/bearing combination must be removed and returned to the factory for rework or replacement.

COMPARISON
SUMMARY SHEET

	Replaceable Wire Race Design		**Gothic Arch Raceways**
1)	Technological Advances Comparable	1)	Technological Advances Comparable
2)	Replaceable wire races specifically, designed for water and wastewater industry.	2)	Gothic Arch Raceways designed for applications with high overturning moment.
3)	Selection of Replaceable Wire Race hardness allows for improved conformance between ball and race that optimizes stress levels.	3)	No improved conformance possible - high stresses must be handled by case hardened material.
4)	Design based on high thrust and high radial loads permitting full complement of balls that roll.	4)	High radial loads cause balls to scuff and slide requiring use of plastic spacers reducing the number of balls by 25%. Radial Bearing capacity average 40% of thrust capacity.
5)	Wire races are replaceable. Designs are for 20-year life plus but due to variations in actual application and maintenance replacement may be earlier or later.	5)	Cannot replace raceway must replace entire Gothic Arch Combination Gear/Bearing.

GEAR

Ductile Iron	Carbon Steel
Upgraded in recent years to an ASTM A536 Grade 120-90-02 heat-treated ductile iron achieving a fine tempered pearlitic micro structure which possesses improved physical characteristics combined with superior corrosion resistance.	Forged carbon steel
With improved design and manufacturing procedures meets an AGMA Class 6 quality and precision standard **after** heat treat.	Claim AGMA Class 6 quality and precision **before** heat treat.
	Note: Raceways are hardened after machining of gear teeth causing distortion. Not sure what precision can be claimed for the gear after raceways are hardened.
Split main gears became possible through improved foundry and manufacturing techniques. The joint geometry has been designed to withstand a momentary peak condition with an adequate safety factor.	Combination gear and bearing designs require bolting of the stationary and rotating elements.

GEAR CORROSION RESISTANCE

Ductile Iron

Ductile Irons have superior corrosion resistance (see WPE paper Comparison of Clarifier Drives, March 2000) when compared with carbon steel.

Carbon Steel

Susceptible to corrosion.

CASE HISTORY I

Time Period – 13 years of service

During this period all of the gears noted below had operated in the same plant with the same maintenance procedures for the same length of time

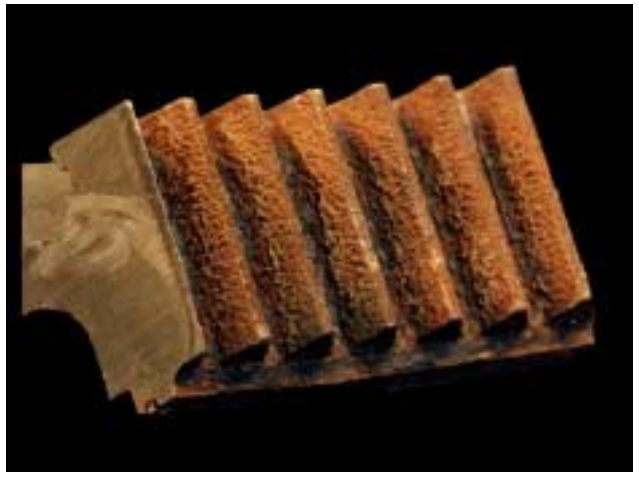
4 Thickeners – 80" P.D. Drive using ductile iron gears. Two were returned for rehab. In both cases the ductile iron gears were re-usable.

12 Clarifiers – 80" P.D. Drives using steel gears returned for rehab Every gear was found to be unusable due to corrosion.

CASE HISTORY II

The superior corrosion resistance of ductile iron gears is seen in a segment of a used 80" ductile iron gear that had 20 years of service of Appleton Paper Co., in Combined Locks, Wisconsin. This gear was replaced by the Paper Company even though the corrosion was so slight, WPE felt it could be salvaged. As a result, it had twenty years of service in a paper mill and then sat out in our yard for the next six years, twenty-six years in total.

D.I. Gear 20 yrs of service and 6 yrs outside storage



Steel Gear after 13 yrs of Service

GEAR
SUMMARY

Walker Process Equipment offers:

- An upgraded ASTM A536 Grade 120-90-02 heat treated ductile iron achieving a fine tempered perlitic micro structure with:

    1) Improved physical properties
    2) Superior corrosion resistance

- AGMA Class 6 Quality and Precision **after** heat treat

- Ability to replace wire races and balls as needed.

L10 BEARING LIFE CALCULATIONS

For Gothic Arch Combination Gear and Bearing

There is no accepted industry-wide standard for rating the capacity of large diameter gothic arch bearings.

The ABMA 1990 rating presumes infinitely rigid mounting structures, perfectly flat mounting surfaces and a raceway that is through hardened versus the case hardened designs and bearing balls that roll.

Some suppliers of gothic arch drive assemblies for circular clarifiers claim L10 life using equivalent thrust forces only in the calculations. More appropriate calculations would utilize equivalent radial loads that on average generate a L10 life 60% lower. This still does **not** take into consideration the scuffing and sliding action of the bearing balls induced by high radial loads.

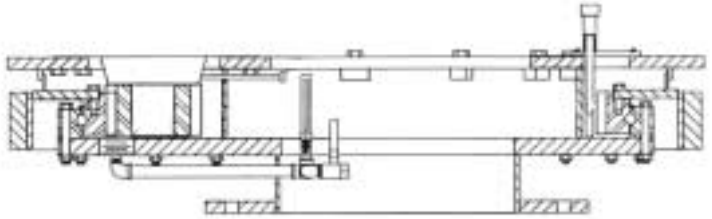
The ABMA 1990 rating is simply for informational purposes and **should not** be considered in the bearing selection process.[1]

[1] Avon Bearing Literature

HOUSINGS

CAST IRON

FABRICATED STEEL



HOUSING
Technology

In early 1900's there was a great preference for cast iron for a wide range of products. With the advent of newer steels and new welding techniques, many products were switched to weldments to achieve:

a) Reduction in weight
b) Reduction in cost
c) Reduced investment (i.e. elimination of patterns) needed to get into a particular business.

However, many products have remained as castings in spite of the savings due to concerns about specific design requirements such as corrosion resistance, rigidity and others. Pumps, drives, turbines, valves, and many others fit into this category.

Cast Iron

Cast iron does not elongate with tensile forces and can accept compressive forces that exceed carbon steel giving it the ability when properly designed to provide a stable mounting platform.

Walker Process Equipment cast iron housings are designed with substantial wall thickness and gussets to provide superior geometry for rigidity, support and dampening properties, thereby ensuring proper alignment and meshing of gear teeth.

Fabricated Steel

Carbon steel fabricated structures utilize the higher tensiles available to reduce wall thicknesses and eliminate weight. Note: steel elongates with increased tensile loadings following its yield curve.

Fabricated structures flex proportionately to selected material thicknesses and other design decisions.

The gothic and combination gear and bearings by design require mounting surfaces that are flat and rigid with unpainted machine surfaces, (see example for raceways diameters up to 40"[(1)].

Table 1	**Table 2**
Initial Mounting SW Face Error	Maximum Deflection Under Peak Operation Loads
.006'	.024'

[(1)] Reference: Avon Bearing Literature

HOUSING

Cast Iron

Cast iron is corrosion resistant and in 56 years of manufacturing Walker Process Equipment is unaware of any housing failing due to corrosion.

Cast Iron is the material of choice for many products where rigidity, support and corrosion resistance is required. The casting industry continues to:

a) Upgrade materials
b) Improve foundry practices
c) Maintain high quality control standards

Fabricated Steel

Fabricated steel housings require coatings that have a varying life. The quality of the welding and the standard of smoothness i.e., NACE "C" or less also impact the anticipated life of corrosion preventative coatings.

Unpainted fabricated carbon steel structures have the same susceptibility to corrosion as unpainted carbon steel gears

Fabricated housings require the same standards of quality to ensure:

a) Material quality
b) Welding uniformity
c) Welding quality to prevent cold welds, inclusions, undercuts, voids, etc.

SUMMARY

Cast iron housings meet the specific needs of the application to provide a stable platform to ensure gear alignment and resist corrosion.

LUBRICATION

REPLACEABLE WIRE RACES

OIL

Provides a constant source of lubrication from an oil reservoir that extends 360° around the drive.

Oil should be used as the lubricant unless operating conditions preclude its use. (Reference [1] Errichello)

Condensate occurs at varying rates depending on climatic conditions. Oil lubrication allows condensate to sink to the bottom of the drive without emulsifying and drain down a sloping floor to appropriate collection sites to be drained.

Contamination from wear particles settle and are readily removed by draining and replacing the oil.

As a result of a sloping floor and the collection of water at specific locations, Walker Process Equipment is able to offer an Automatic Condensate Removal System (Patent Applied For).

GOTHIC ARCH

GREASE

Continuous operation combined with high loads require recommended greasing every 8 hours (3 times a day) or more often[1].

No visual means of ensuring that grease is being applied equally to all surfaces. Plugging coring and less than desired coverage may occur and not be detected.

Water does not sink through grease. There is no way to effectively drain it. To an unknown degree it will emulsify with grease depending on amount of condensate accumulated over time.

Particulate matter and contaminants become entrained in grease.

OIL

Fabricated housings currently have flat bottoms resulting in water being dispersed underneath the oil with no central collection point.

[1] Avon Bearing Literature

References:

1) Gear lubrication – Part III – Gear Technology – July/August 1991 by Robert Errichello, GearTech, Albany, GA. Mr. Errichello is principal in GearTech a gear consulting firm in Albany, GA.

Note: Robert Errichello's article won the STLE's 1990 Wilbur Deutch Memorial Award for the best article on the practical aspects of lubrication. Mr. Errichello is a member of ASME, AGMA and is a Registered Professional Engineer in the State of California.

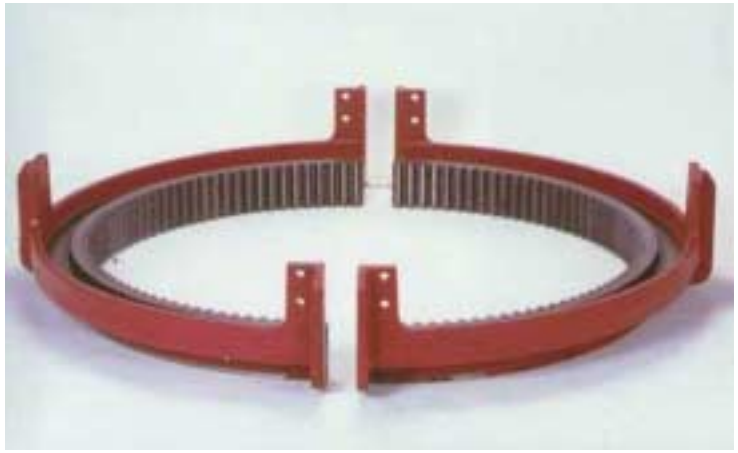
Excerpts .....Grease is suitable only for low speed <u>low load</u> applications…..
.....Contamination from wear particles or other debris is usually trapped in grease.
.....Oil should be used as the lubricant unless the operating conditions preclude its use.

2) Dudley's Gear Handbook
3) ASME Wear Control Handbook
M. Peterson & W. Winer ASME 1980
4) Surface Deterioration of Gear Teeth
J. O. Almer 1950

MAINTENANCE
GEAR AND BEARING

WALKER PROCESS EQUIPMENT

The gear can be disassembled by removing a few bolts that hold the two halves together without removing covers, reducers, motors, torque indicators and pinions:

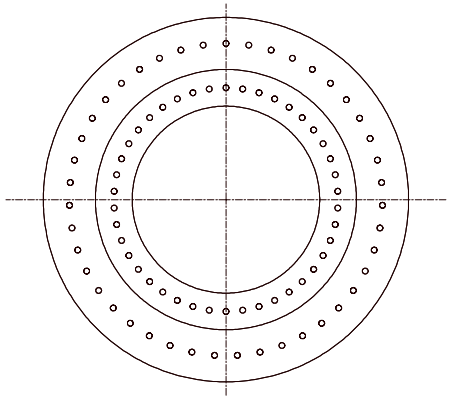


Normal Gear P.D.	No. of S.A.E. Grade 8 Bolts
42”	6
60”	8
80”	8

Reassembly after complete inspection of wire races and roller balls requires only the assembly and pre-torquing of the quantity of SAE Gr 8 bolts noted.

GOTHIC ARCH COMBINATION GEAR AND BEARING

Current designs require complete removal of covers, reducers, motors, torque indicators and pinions in order to then disassemble the many bolts used to secure the combination gear/bearing noted below.



80” Gear/Bearing representation.

Normal Gear P.D.	No. of S.A.E. Grade 8 Bolts
42”	65
60”	75
80”	85

Re-assembly requires the tightening in recommended sequence the indicated quantity of SAE Gr 8 bolts noted to the required level of pre-load plus re-assembly of the pinion, torque indicators, motors, reducers and covers.

NOTE: Individual manufacturers vary in number of required bolts.

INTERMEDIATE DRIVE

WALKER PROCESS EQUIPMENT WORM GEAR

Specifically designed for low speed, high torque continuous operation in adverse conditions featuring:

a) A corrosion resistant housing
b) Oil lubrication with drain to remove condensate and particulate matter
c) Ease of inspection
d) Few parts to assembly and disassemble

GOTHIC ARCH OPTIONS

1 - Cycloidal Gear Box – Westech

See SM-CYCLO Speed Reducer

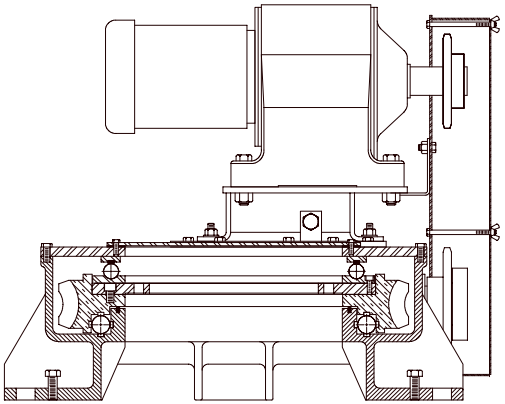
2 - Planetary Gear Box – DBS

See Fairfield – Torque Hub Final Drive

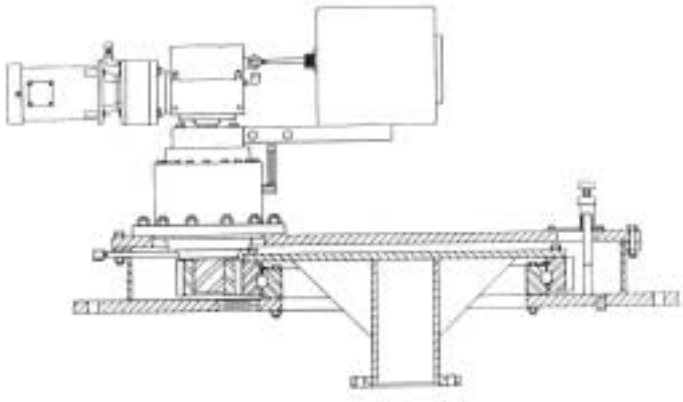
Assembly and disassembly of both designs is complicated and involves many parts.

BRIDGE SUPPORTED DRIVE

WALKER PROCESS EQUIPMENT



GOTHIC ARCH

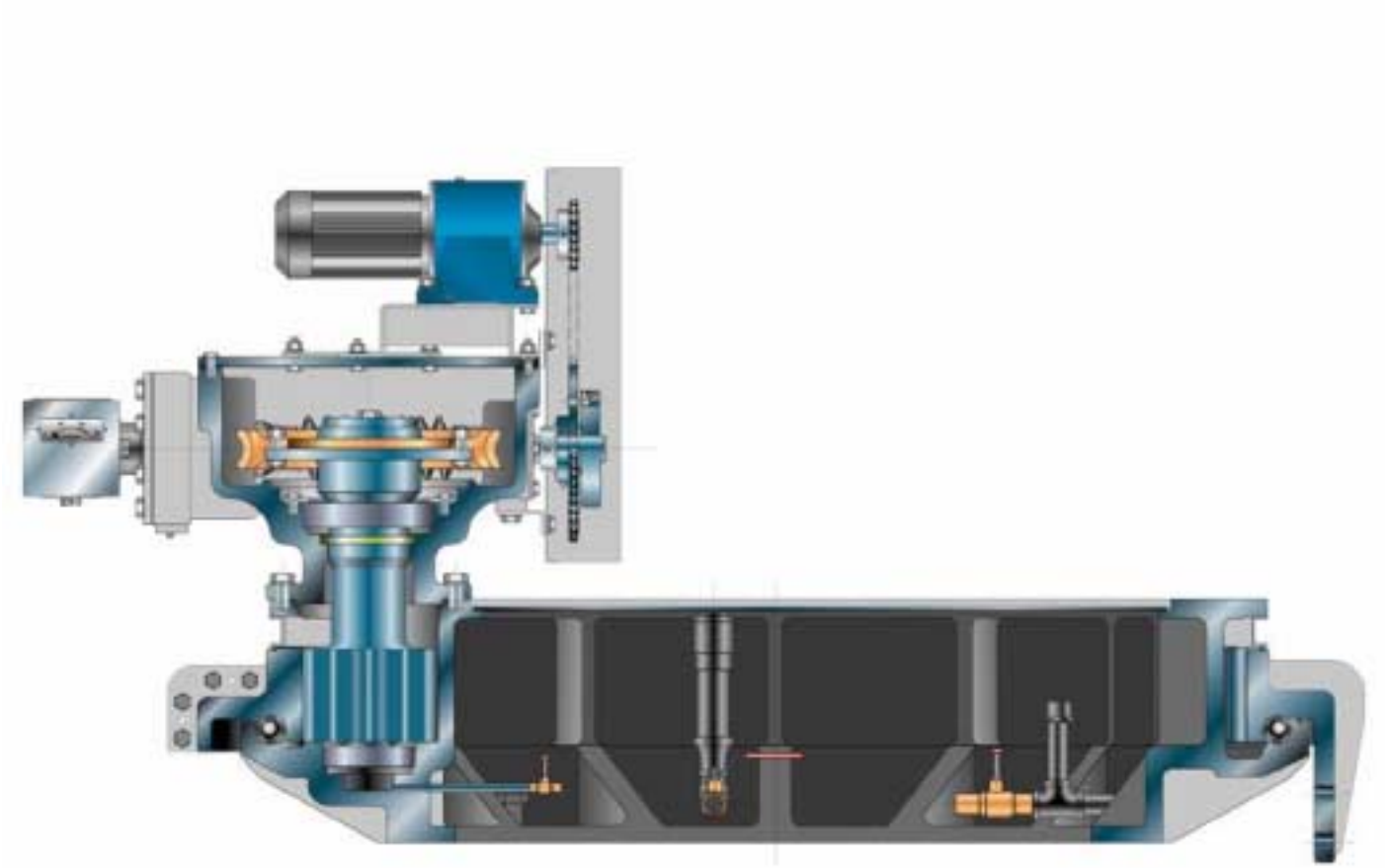


OVERALL SUMMARY

Walker Process Equipment offers modern technology specifically applied to circular clarifiers.

1) Higher AGMA **quality** and **precision** ratings after heat treat
2) **Conformance** between races and bearing balls with lower stress and more bearing balls for a given diameter
3) **Inspection and replacement** of races and bearing balls when necessary with significantly greater ease of disassembly and assembly.
4) Material selections for main gear and housings that are **corrosion resistant.**
5) Material selections for main gear housing combined with geometry provide **superior rigidity support and dampening properties** providing a stable platform for gear alignment.
6) **Oil lubrication**, which is the preferred system, particularly when the application calls for high loads, slow and continuous operation in adverse environments.
7) Special consideration has been given to **removal of water and contamination.**
8) The worm gear drive is significantly **easier to maintain**, has fewer parts.

THE CHAMP



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