

WahlcoMetroflex, Inc.

Isolation Equipment for Gas Turbine Applications

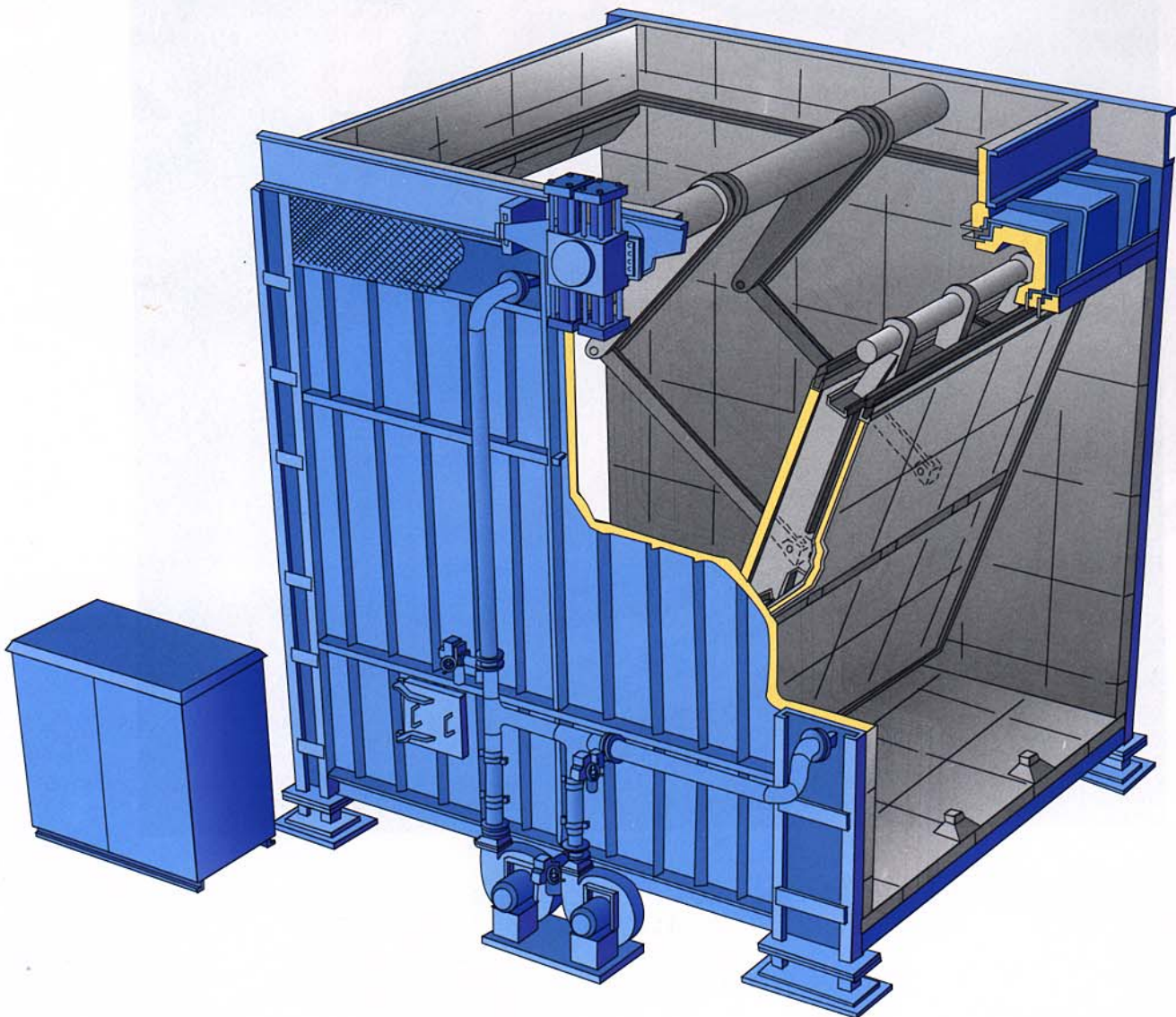


Toggle Drive Design Overview

WahlcoMetroflex Diverter Valves (WDVs) have been developed using technology from both Bachmann Industries, Inc. and Metro-Flex which *WahlcoMetroflex* purchased in 1990 and 1991, respectively. Although the current WDV designs utilize features found on both Bachmann and Metro-Flex™ designs, they also have many new innovations that improve diverter operation while reducing pressure drop.

WDVs are available in several standard sizes and configurations. In addition, *WahlcoMetroflex* can provide custom sizes to meet specific project requirements.

WahlcoMetroflex has supplied over 600 single blade diverters since 1976, or over 80% of world's diverters used in combined cycle operations for turbines over 70MW.



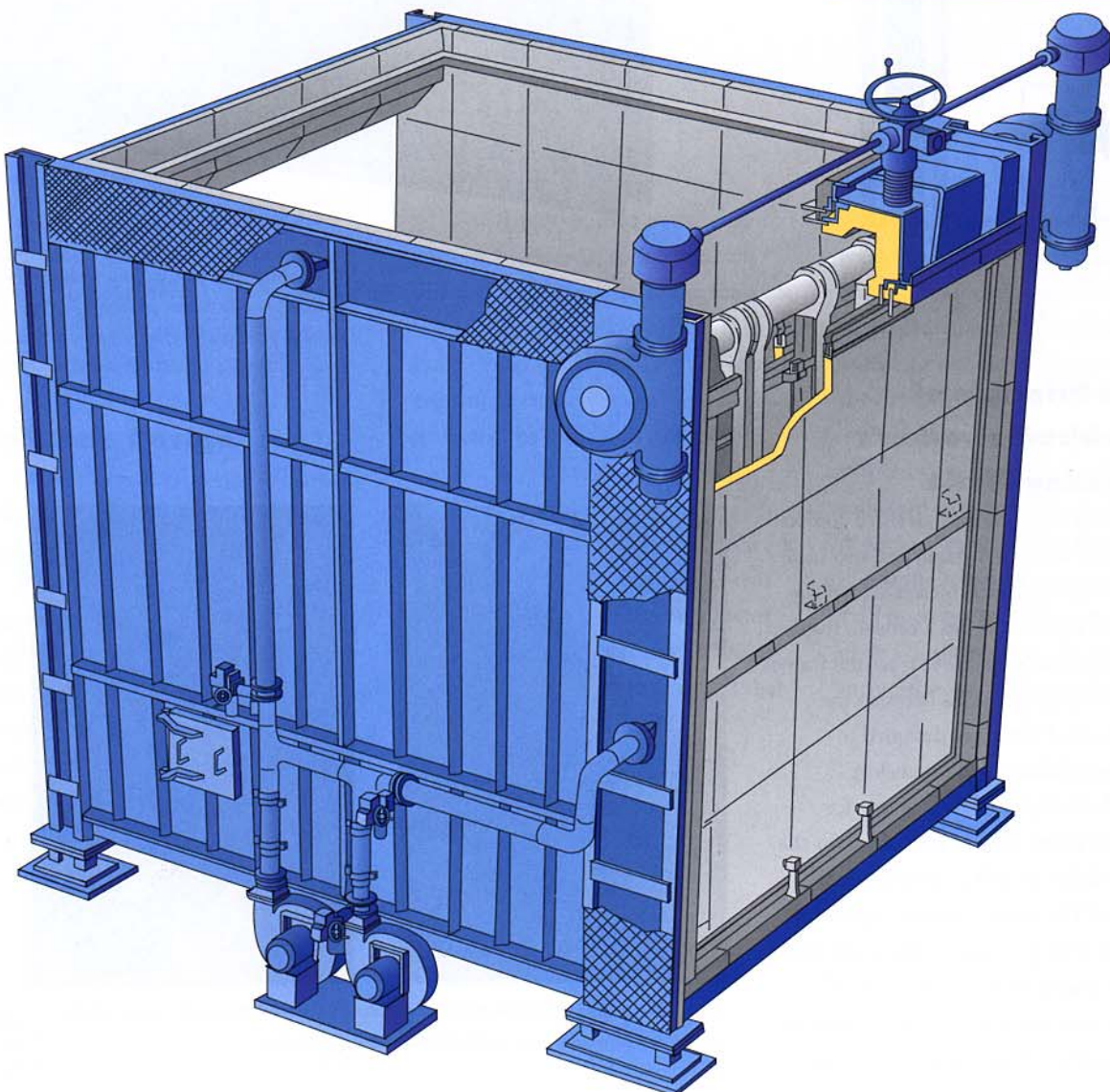
Pivot Drive Design Overview

For most diverter sizes, several options are available. The illustrations on page 2 and 3 show some of these options, including: electric or hydraulic drives, and pivot or toggle arrangements. These options and others are more fully described in the following pages.

WahlcoMetroflex's designs can accommodate a variety of aspect ratios and internal and external insulation

configurations. Vertical shaft units are available for side discharge applications. Options such as inclined blades and integral turning vanes are also available.

Standard diverter sizes and configurations are offered for many large gas turbine models, as shown on page 10.

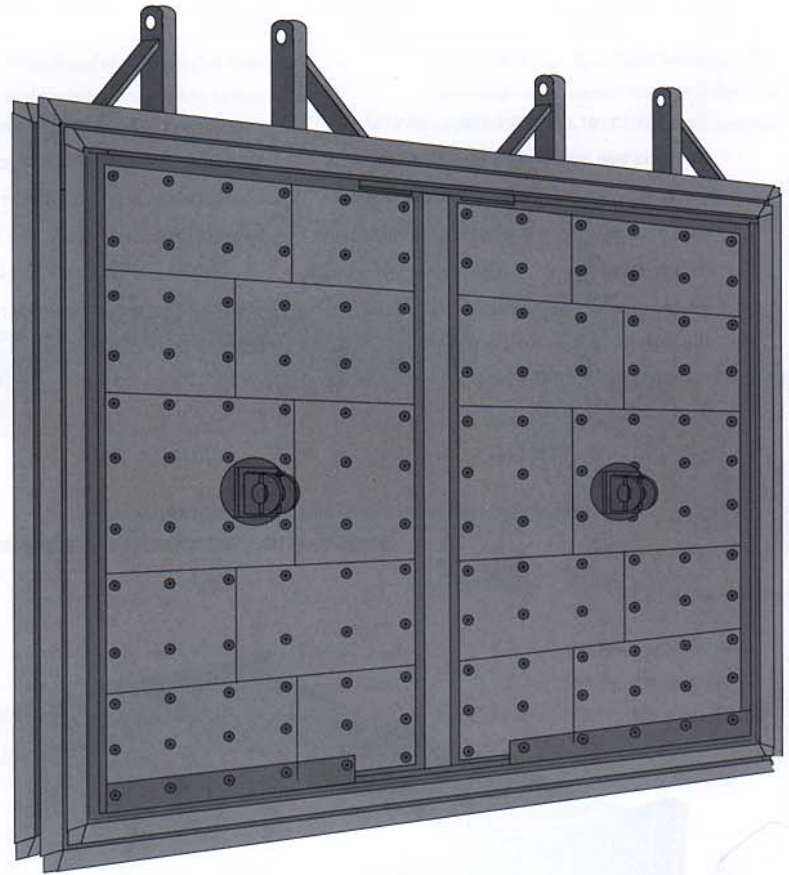
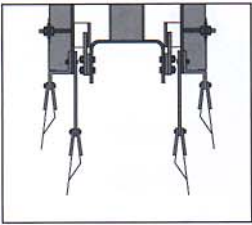


Toggle Diverter Blade

Stainless Steel Liner
Panels

Blade Insulation,
typically 76mm (3")

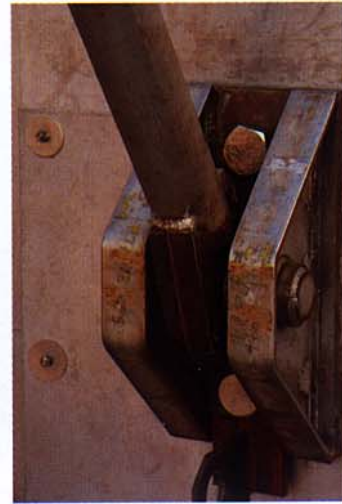
Seals are Blade-
Mounted (see page 6)



WahlcoMetroflex pioneered the floating blade design which allows the blades on each side of the structural frame to grow independently during thermal changes.

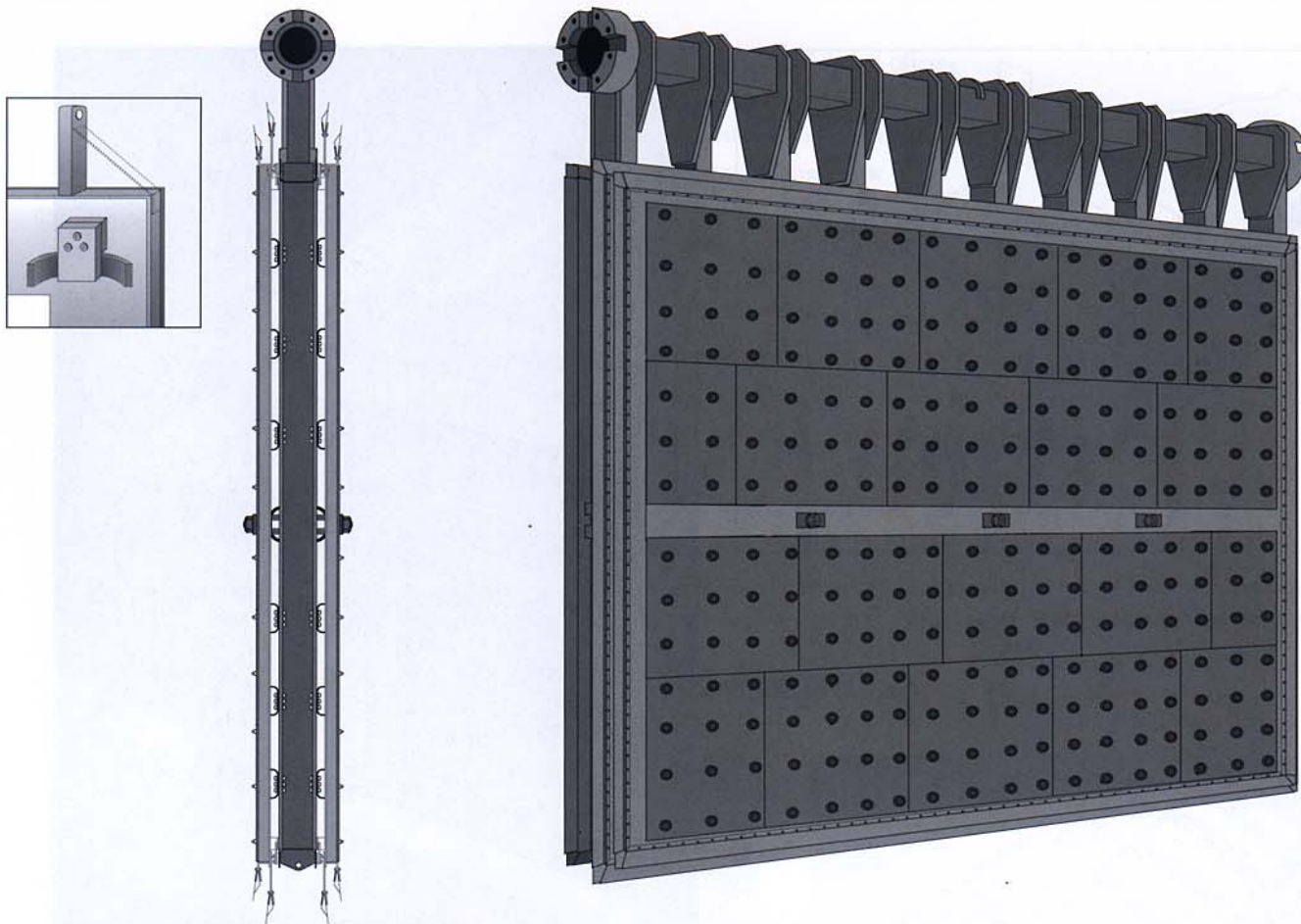
The Principle of WahlcoMetroflex's Floating Blade

The blade consists of three components: a structural frame and two blades which are attached to each side of the frame. Each blade has a central, fixed point connected to the structural frame. All other connections between the blades and frame are designed to accommodate radial expansion. WahlcoMetroflex's design allows for independent rates of expansion for the two blades, as well as their structural frame. The frame is always exposed to gas flow which reduces stress and fatigue. The unique duplex sealing system (discussed in detail on page 6) does not contact the blade's structural frame.



WahlcoMetroflex's toggle linkage provides a significant mechanical advantage which reduces torque requirements and helps stabilize large blades.

Pivot Diverter Blade (SDV)



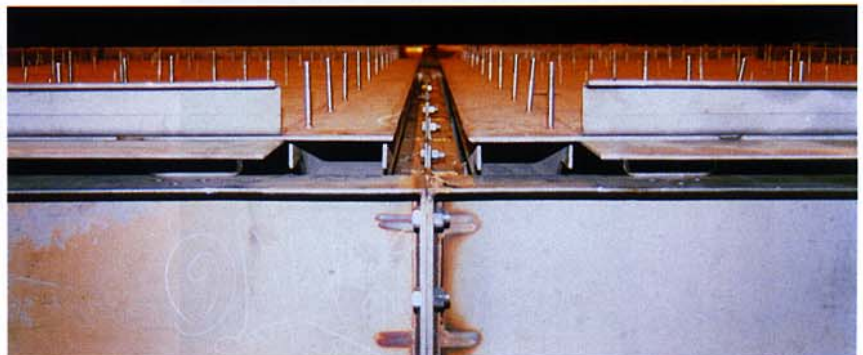
Pictured above is the blade frame for a WDV-TE-7A (toggle drive) blade.

Toggle and Pivot Drive

WahlcoMetroflex offers both toggle and pivot drive systems. Pivot drives are offered with rectangular or square gas paths, with blade heights up to 4267mm (14'). Toggle drive units are available in all sizes, with either rectangular or square gas paths.

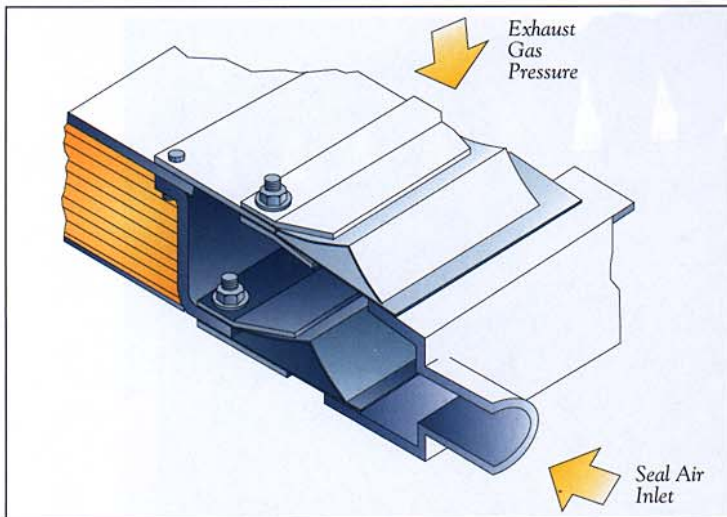
Stress Analysis

To assure accurate analysis of stresses and deflection, WahlcoMetroflex uses finite element analysis techniques to model thermally-induced and structural stresses.

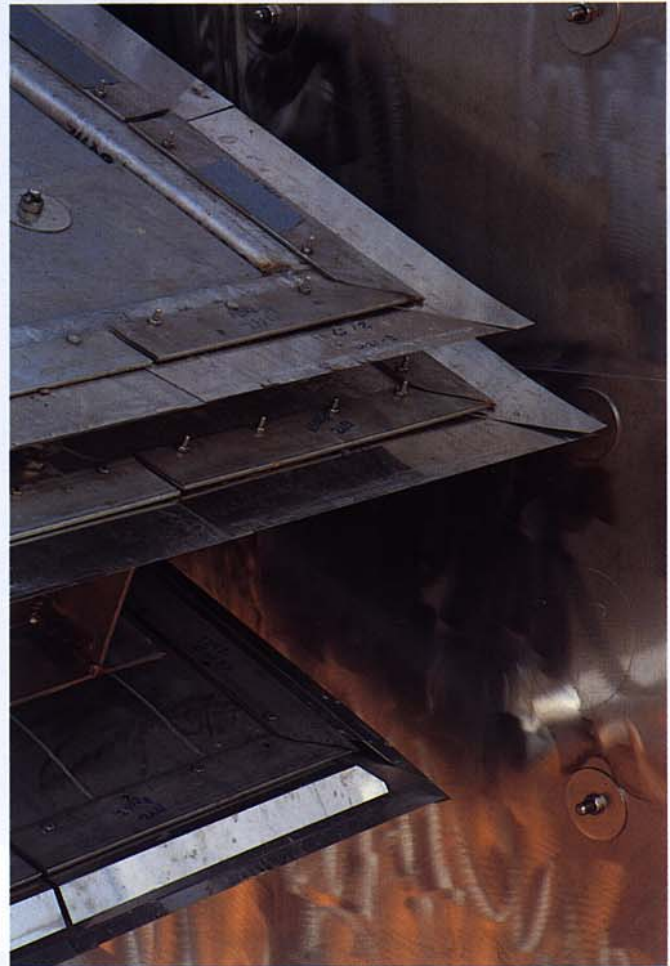


A blade is mounted on the structural frame and awaits insulation and alloy liner panels.

Duplex Seal



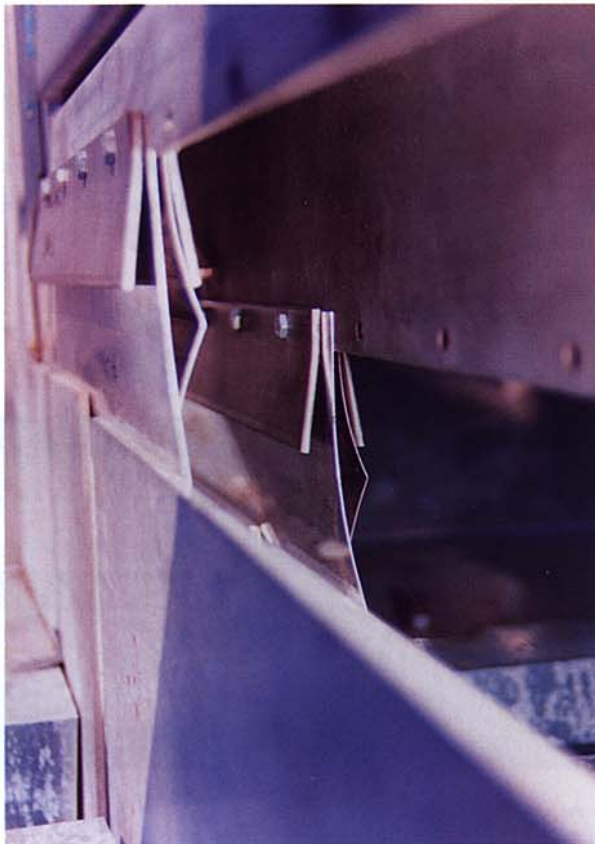
Metallic seats (typically INCONEL® 625) are "pressure assisted." This means that the gas pressure maintains the seals against the sealing surface.



Seals that are segmented to allow for expansion. Field tests on large units have shown leakage of less than 0.01% without seal air. A low capacity seal air fan permits 100% isolation.

Patented Seal Design

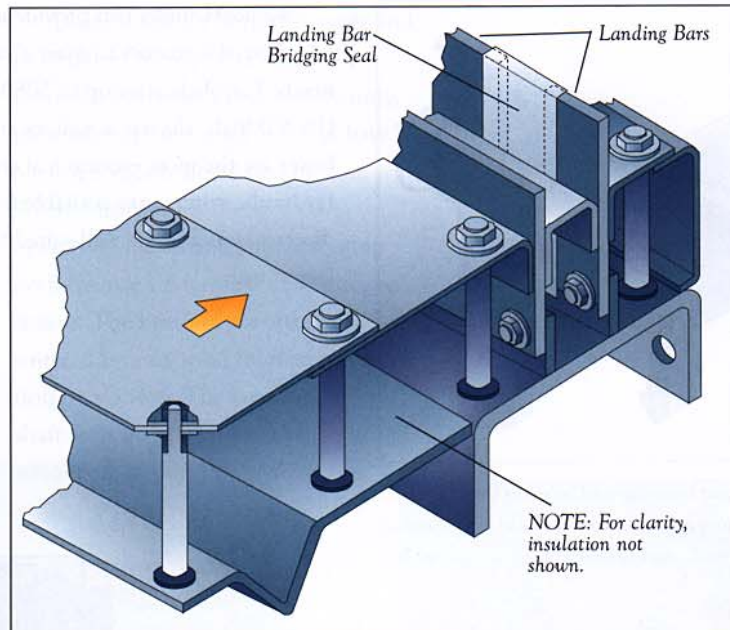
WahlcoMetroflex's patented seal design consists of a primary seal, bias spring, and anti-vibration clamping bars. The primary seal is pre-deflected and straightens out when in contact with the sealing surface. This design assures a positive seal between the blade and the sealing surface, while compensating for up to 20mm (3/4") misalignment.



With a portion of the seals removed the corner seals can be seen with the blade in the closed position.

Internal Insulation & Seal Air Cavity

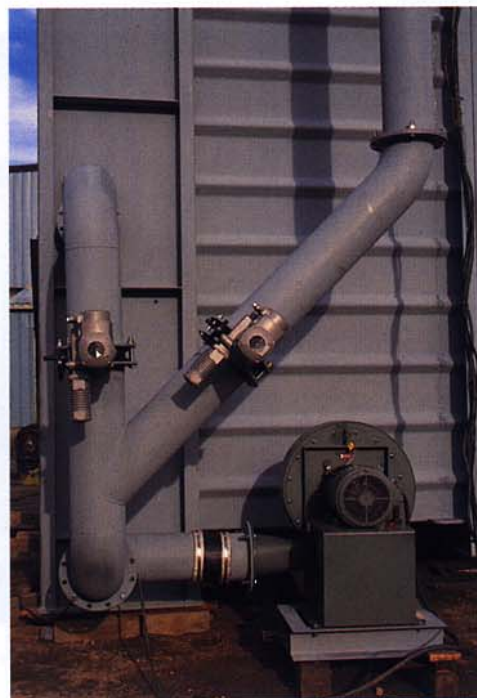
The most economical configuration provides seal air only to the HRSG port. However, when required, seal air systems can provide zero leakage to either the bypass or HRSG ports. Seal air systems do not improve thermal efficiency and should only be specified when zero leakage is required.



As pictured above, the landing bars are segmented to allow for thermal expansion with minimal distortion. Landing bars are bolted to the frame utilizing oversized holes. A small bridging seal covers the gap between segments.

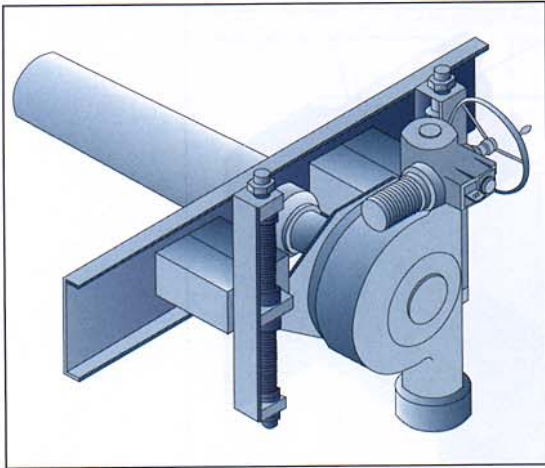
Seal Air System

Seal air systems generally consist of a seal air fan, isolation valves, and piping to the bypass and HRSG ports. *WahlcoMetroflex* recommends skid-mounted fans to minimize vibration. Redundant fans can be provided if required.

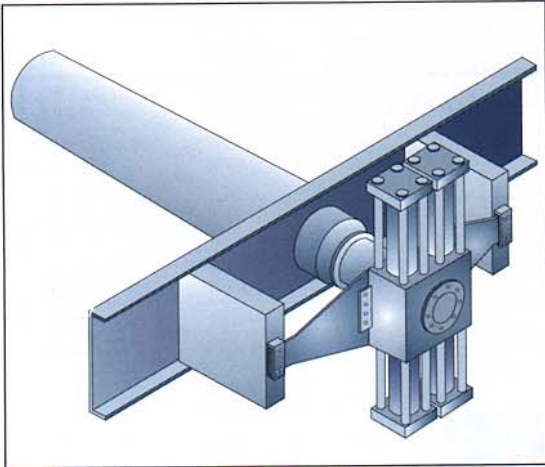


Long radius piping bends are used to minimize seal air pressure losses.

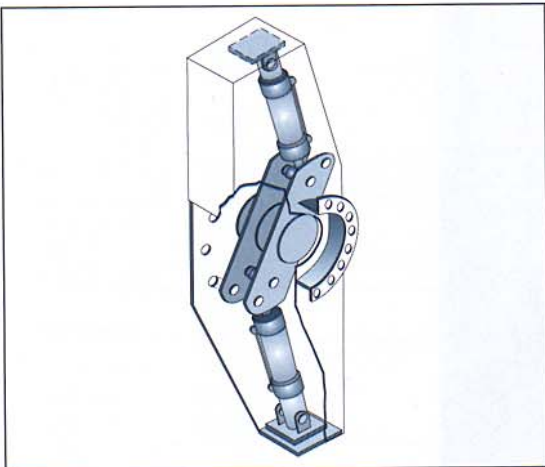
Drive Options



Electric actuator and gear boxes are used on many units. The gearboxes are shaft-mounted to reduce the overhang load. External spring packs act as thermal compensators to maintain proper drive alignment.



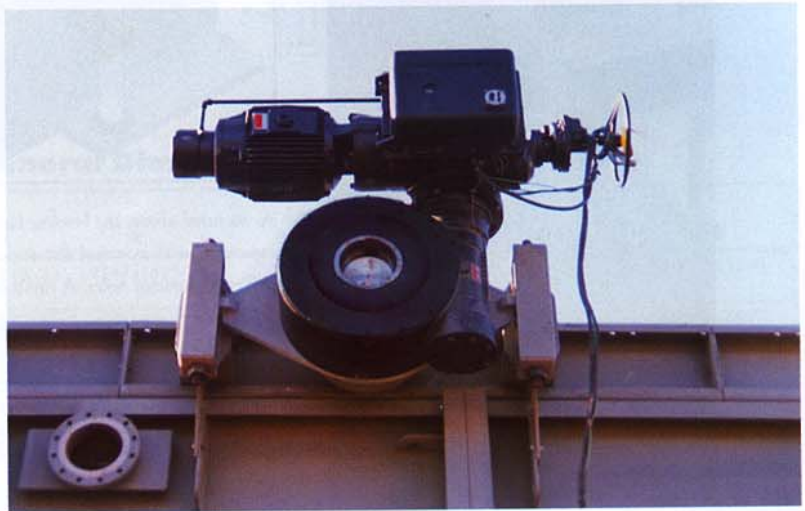
Double-acting hydraulic rams are used for toggle drive actuators.



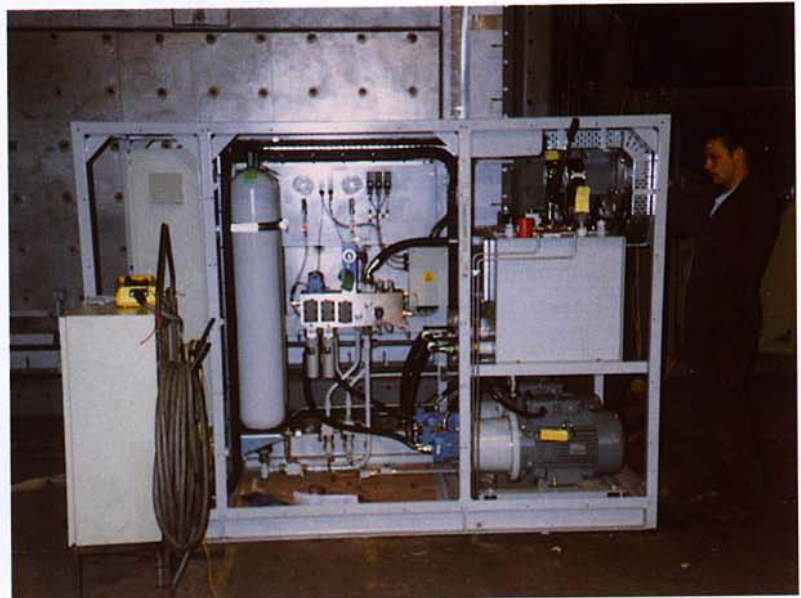
Double-acting hydraulic pistons are used on pivot drive models.

WahlcoMetroflex can provide a wide selection of actuators to meet a variety of needs. For blade sizes up to 5080mm (16' 8") high, electric actuators and gear boxes are the most economical choice. Hydraulic systems are available for all diverter sizes and are well-suited for the largest units.

Thermal compensation systems are designed to accommodate thermal growth of the drive shaft and linkage. (See illustration.) This arrangement maintains proper alignment between the drive shaft and actuator, while allowing the components to move and grow when hot.

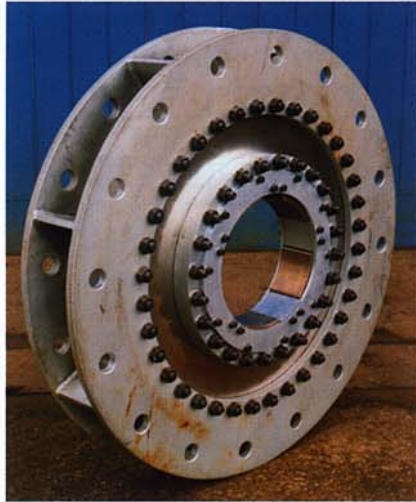


Electric actuators provide an economical drive system for small and medium-sized diverters.



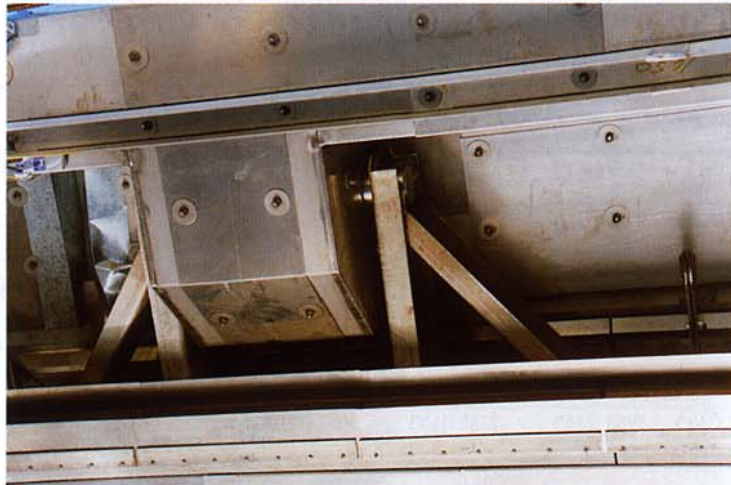
Hydraulic power units provide the torque required for large toggle and pivot drive diverters.

Bearing Design

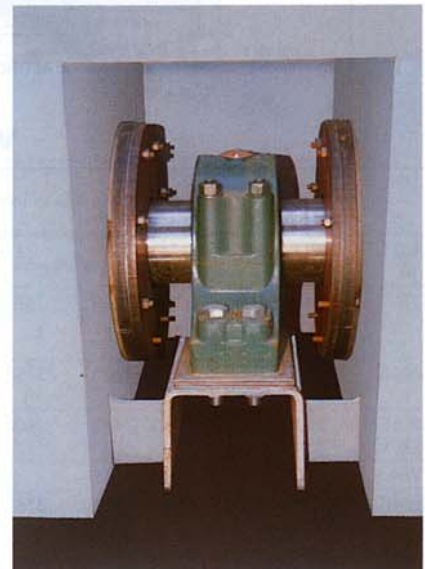


Pivot bearing.

Blade shafts for both the toggle and pivot drives incorporate externally-mounted bearings. These self-aligning, permanently-lubricated bearings have been specifically developed by *WahlcoMetroflex* for diverter valve operation; i.e. reliable, non-jamming performance under slow shaft-turning speeds. The bearings are either of sintered bronze/solid lubricant formulation or SG iron. The bearings' metallic shaft seals do not interfere the bearings' self-alignment.



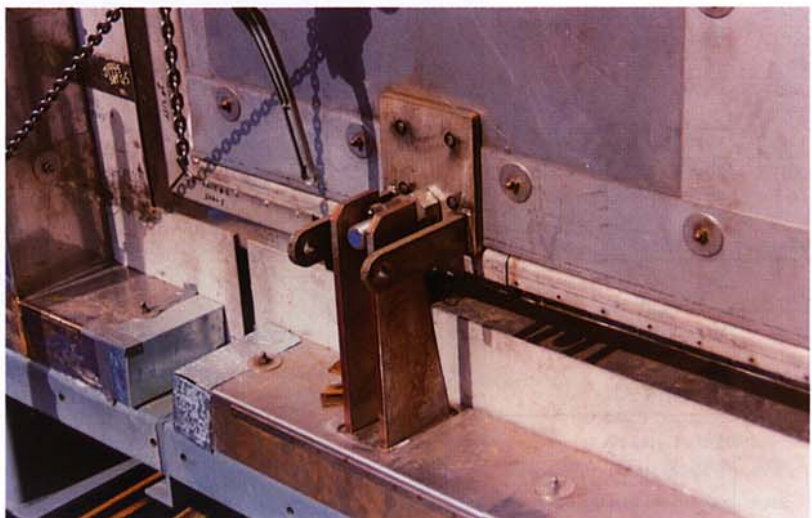
Close-up of toggle drive pivot shaft, viewed from inside diverter box.



Permanently-lubricated bearings are mounted external to the gas path.

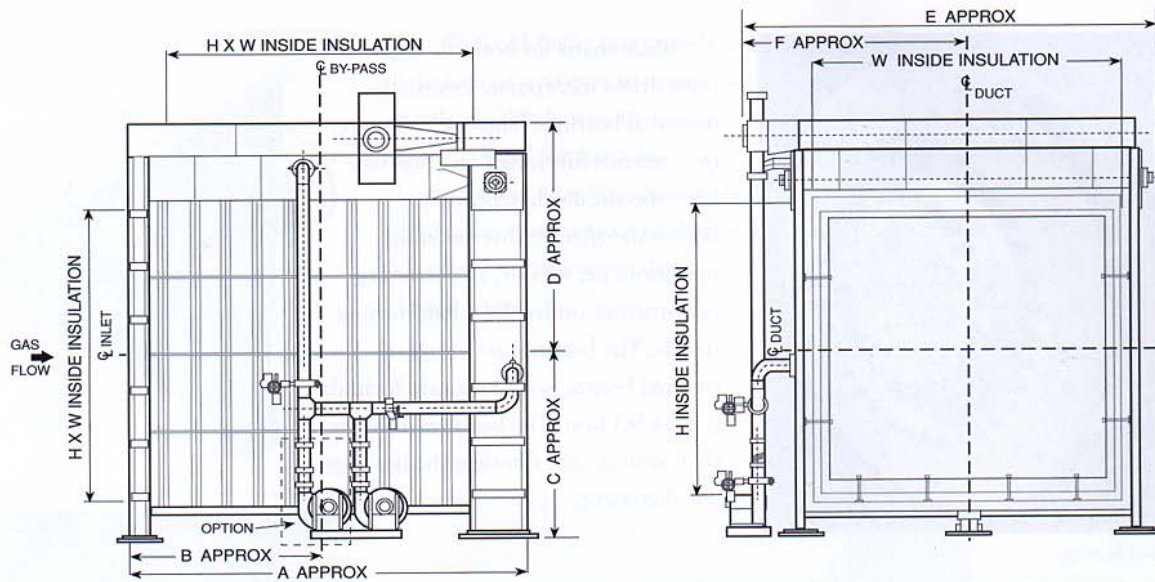
Blade Stops

Blade stops are integral with *WahlcoMetroflex* diverter blades. Frame-mounted blade stops having adjustable bolts are set to align the blade seals properly with the landing bar. The blade stops prevent over travel and extend seal life. Locking pins, as shown in the adjacent photo, provide a positive means of securing the blade position for shipment and open cycle operation.



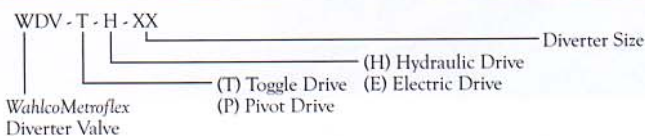
Blade stop

WDV General Dimensions



WDV General Dimensions

Turbine	Diverter	Inlet W x H (or Dia.)	Outlets W x H	A	Approximate dimensions mm/inches			
					B	C	D	E
GE LM2500 ABB GT 10	WDV-P-E-4	2438 (96")	2438 (96") x 2438 (96")	4159 (164")	1872 (74")	2172 (85.5")	2287 (90")	4544 (179")
GE PG 5371 LM 5000 LM 6000	WDV-P-E-5 WDV-T-E-5	2667 (102")	2667 (102") x 2667 (102")	4388 (173")	1987 (78")	2287 (90")	2402 (94.5") 3002 (118")	4773 (188")
GE MS 6001B MW 251	WDV-P-E-6 WDV-T-E-6	3050 (120")	3050 (120") x 3050 (120")	4771 (188")	2178 (85")	2478 (97.5")	2593 (102") 3193 (126")	5156 (203")
GE MS 6001FA ABB GT8 B/C	WDV-P-E-7 WDV-T-E-7	3600 (144")	3600 (144") x 3600 (144")	5321 (209.5")	2453 (96.5")	2753 (108.5")	2868 (113") 3468 (136.5")	5706 (224.5")
Siemens V64.3	WDV-T-H	discuss with WahlcoMetroflex						
GE MS 7001EA	WDV-P-E-7A WDV-P-H-7A WDV-T-E-7A WDV-T-H-7A	4267 (168")	4267 (168") x 4267 (168")	5988 (236")	2787 (110")	3087 (121.5")	3202 (126") 3202 (126") 3802 (149.5") 3802 (149.5")	6373 (251")
ABB GT 11N MW 501D	WDV-P-H-8 WDV-T-E-8 WDV-T-H-8	4724 (186")	4724 (186") x 4724 (186")	6445 (254")	3015 (119")	3315 (130.5")	3430 (135") 4030 (159") 4030 (159")	6830 (269")
ABB GT 11N2 ABB GT 13D GEPC9171E MW 501F	WDV-P-H-9 WDV-T-E-9 WDV-T-H-9	5080 (200")	5080 (200") x 5080 (200")	6801 (268")	3193 (126")	3493 (137.5")	3608 (142") 4358 (172") 4358 (172")	7186 (283")
Siemens V84.2	WDV-T-H	discuss with WahlcoMetroflex						
GE MS 7001FA ABB GT 24	WDV-T-H-9A	5468 (216")	5468 (216") x 5468 (216")	7189 (283")	3387 (133")	3687 (145")	4552 (179")	7574 (298")
Siemens V94.2 Siemens W84.3	WDV-T-H	discuss with WahlcoMetroflex						
ABB GT 13E/2	WDV-T-H-10	6000 (236")	6000 (236") x 6000 (236")	7721 (304")	3653 (144")	3953 (156")	4818 (190")	8106 (319")
GE MS 9001FA ABB GT 26 MW 701F	WDV-T-H-10A WDV-T-H-10A	6400 (252")	6400 (252") x 6400 (252")	8121 (320")	3853 (152")	4153 (163.5")	5018 (197.5") 5018 (197.5")	8506 (335")
Siemens V94.3	WDV-T-H	discuss with WahlcoMetroflex						
Rectangular	Diverter	All apertures		A	Approximate dimensions mm/inches			
		W	H		B	C	D	E
GE PG 9171E MW 701D MW 701F	WDV-P-H-9R WDV-P-H-9AR WDV-P-H-10AR	6489 (259.6")	3750 (150.0")	5421 (216.8")	2503 (100.1")	2803 (112.1")	2918 (116.7")	8545 (341.8")
		7500 (300.0")	3500 (140.0")	5171 (206.8")	2378 (95.1")	2678 (107.1")	2793 (111.7")	9556 (382.2")
		8500 (340.0")	4550 (182.0")	6221 (248.8")	2903 (116.1")	3203 (128.1")	3318 (132.7")	10556 (422.2")



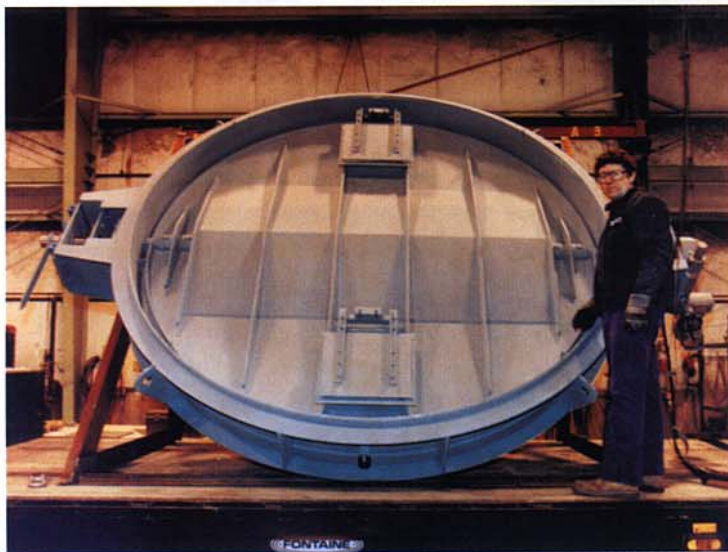
These dimensions not to be used for construction purposes. Certified prints available upon receipt of formal order. WahlcoMetroflex reserves the right to change without notice.

Small Diverter Valve (SDV)



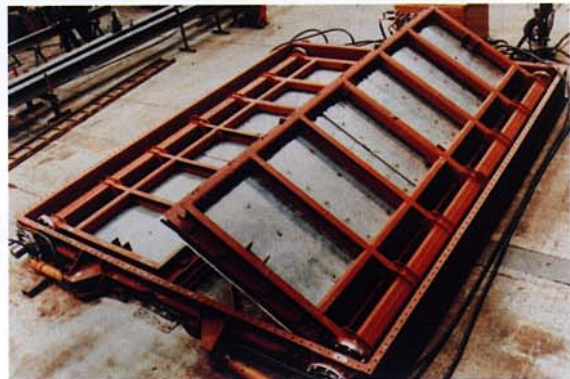
Our economical SDV design offers performance similar to the WDV models but is designed for smaller gas turbines. Electric and pneumatic actuators are available. The SDV shares many design features with its big brother, including the duplex seal design. A simplified blade and frame design are used on these units.

Stack and HRSG Outlet Dampers

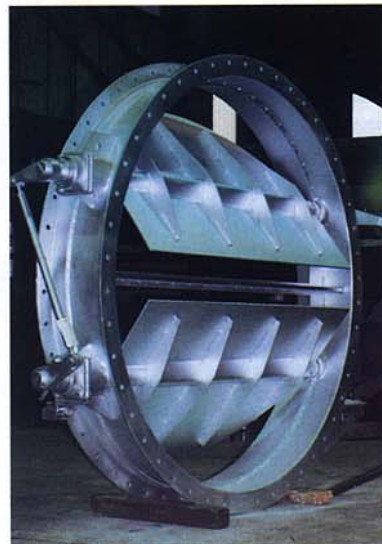


Stack damper with emergency vent panels.

WahlcoMetroflex can provide dampers for HRSG outlets and stacks. Insulated dampers can be used to help maintain system temperatures on peaking or cycling units. Uninsulated dampers can be used to minimize rain ingress. Vent panels can be provided to provide pressure relief in overpressure conditions.



Flap style dampers are often used for square or rectangular stacks.



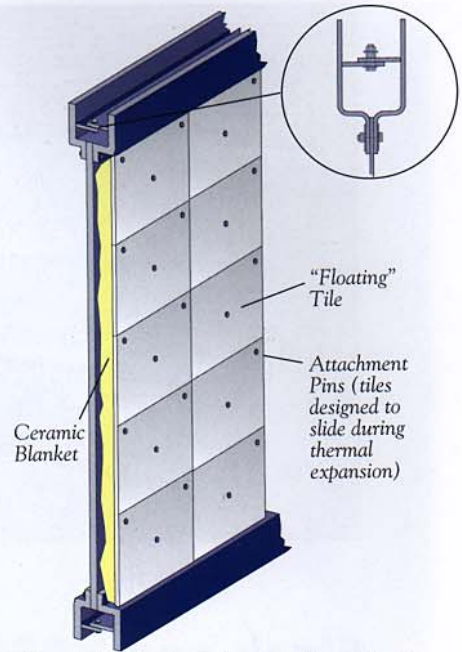
Gas Turbine Guillotine Design



A WahlcoMetroflex guillotine is prepared for shipment. Our blade design can easily accommodate round, square or rectangular duct openings.

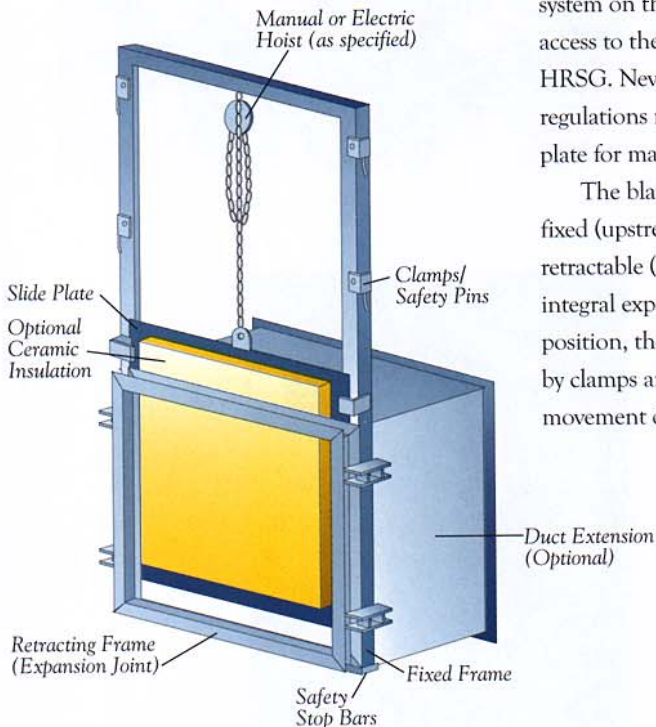
WahlcoMetroflex's unique gas turbine isolation guillotine is designed for high temperature service. The blade membrane can be insulated and floating tiles attached to minimize heat loss. The blade's channel perimeter is split and bolted to allow differential expansion and to prevent distortion.

The guillotine has a bonneted enclosure which should be insulated. Seal air is not required when the blade is withdrawn into the bonnet, so the blade stays hot all the time. This design eliminates the distortion problems found on solid plate designs, which depend on seal air across the throat seal to maintain system integrity.



Ceramic blanket insulation, typically used in gas turbine applications.

Blanking Plate



The WahlcoMetroflex duplex sealing system on the diverter damper allows access to the downstream ductwork/HRSG. Nevertheless, some local regulations require a sliding blanking plate for man-safe access.

The blanking plate frame consists of a fixed (upstream) flange as well as a retractable (downstream) flange with an integral expansion joint. In the up (open) position, the blanking plate is constrained by clamps and pins in order to reduce movement due to wind loading.

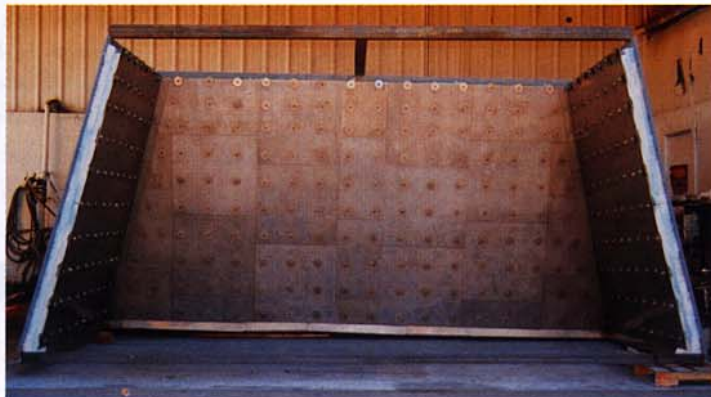
During boiler shutdown, the diverter valve is fully closed to the boiler and the duplex air barrier system is in service. The bolts securing the fixed and retractable blanking plate flanges are removed and the frames split apart using jacking screws located around the fixed flange. The slide plate is lowered into the duct by either an electric or manual chain hoist. The flanges are then bolted together again, clamping the plate securely between them and forming a tight seal.

Vent covers can be incorporated into the duct extension between the plate and the diverter to relieve heat or pressure build-up. Another option is to have the plate fitted with ceramic insulation, although this is not normally required.

Ductwork and Transitions



This round-to-square transition is mounted at the turbine flange. Drain connections and measurement ports are shown.



A duct section during fabrication.

Gas Turbine Intake Isolators

Isolation flaps are now being specified for gas turbine air intake systems so as to prevent windmilling and to retain the heat in a shutdown turbine so that a faster restart is possible.

Fail-Safe Design

WahlcoMetroflex flap-type GT intake isolators are typically located in the vertical intake duct to the gas turbine.

The flap has a counterbalance weight mounted external to the casing in the form of a tube mounted on arms from the end of the shaft. The counterbalance weight is sized such that the flap is always counterbalanced to the open position, thus providing a fail-safe facility.

The flap is retained in the closed position by external spring retainers, which close around the counterbalance weight tube. The retainers hold the blade closed, up to the designed release pressure. In the event of failure of the retainers, the blade falls in a fail-safe manner to the open (safe) position.

The operating system for the flap consists of a "banana" arm connected to the flap shaft and a slotted drive arm connected to the gear motor actuator. There is no direct mechanical connection between the banana arm and the actuator.

Flap closing is performed by a 90° rotation of the slotted arm. Normal opening is initiated by the rotation of the slotted arm until the blade is released from the clips; gravity completes the opening.

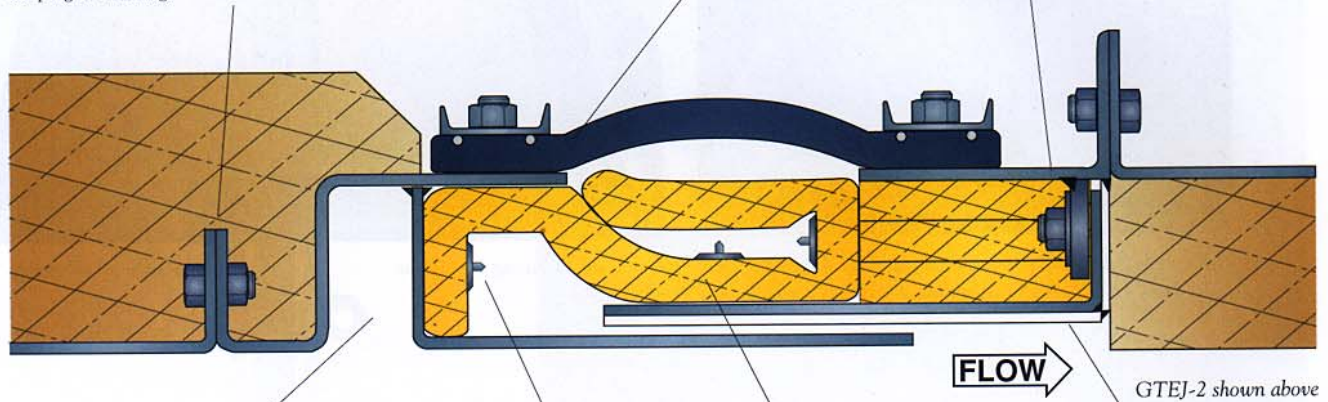
Emergency opening is carried out without power. If the closed flap is subjected to the maximum differential downward pressure, the flap will spring out of the retainers and rotate to the fully open position. It is retained in its open position by a small out-of-balance force provided by the counterbalance.

Gas Turbine Expansion Joints

The joint's flange and the duct's flange are made from like materials and are externally insulated, so they have the same thermal expansion coefficient. This eliminates expansion differences that can produce warping or cracking.

Silica-based cloth is used as insulation underneath the clamping bars to protect the bars and outer cover material against overheating.

WahlcoMetroflex flow liners have specially engineered attachments to allow differential expansion between the hot internal surfaces and the cold exterior frame.



A thermal cavity allows the even distribution of heat along the entire length of the joint's inlet frame, minimizing the frame's expansion differentials.

Pins and clips attach the ceramic material to both the inlet and outlet liners, allowing the flexible insulation to fully expand after each compression cycle.

Flexible ceramic material insulates the joint cavity and is an acoustical barrier. The insulation is wrapped in stainless steel wire mesh and a high-temperature, silica-based cloth to prevent erosion.

Short corner Liner sections allow the free floating side liners to expand without corner cracking.

The Unique Challenge Of GTEJs

Gas Turbine Expansion Joints (GTEJs) must withstand the potential for stress caused by the rapid temperature rise of gas turbine start-ups. By accommodating sudden thermal growth, WahlcoMetroflex GTEJs can avoid warping, binding, cracking and gas leakage.

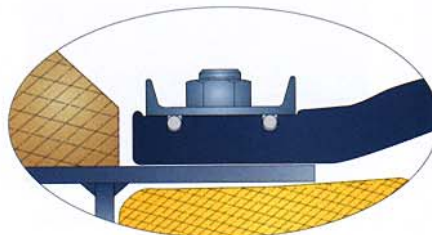
WahlcoMetroflex Designs Anticipate & Minimize Thermal Stresses

Numerous WahlcoMetroflex design techniques are used to combat the thermal extremes faced by expansion joints operating under gas turbine exhaust temperatures of 454°C to 676°C (850°F to 1,250°F).

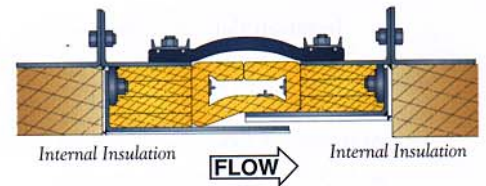
- Wherever hot metal components are permanently joined or fastened to one another, they are made of like materials.

This means their thermal growth coefficients will be the same—eliminating the potential for damaging stress.

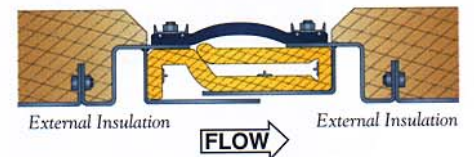
- By controlling the length of liners attached to the frame, we greatly reduce the threat of binding, warping and cracking due to thermal differentials.
- Careful attachment of joint cavity insulation (also known as the "Dome Seal") allows the insulating materials to fully expand after compression. This eliminates "hot spots" on the fabric belt that could cause early failure.



Close-up of the Key Mounting System used to attach the fabric belt to the joint's frame.



GTEJ-1: Cold Frame to Cold Frame

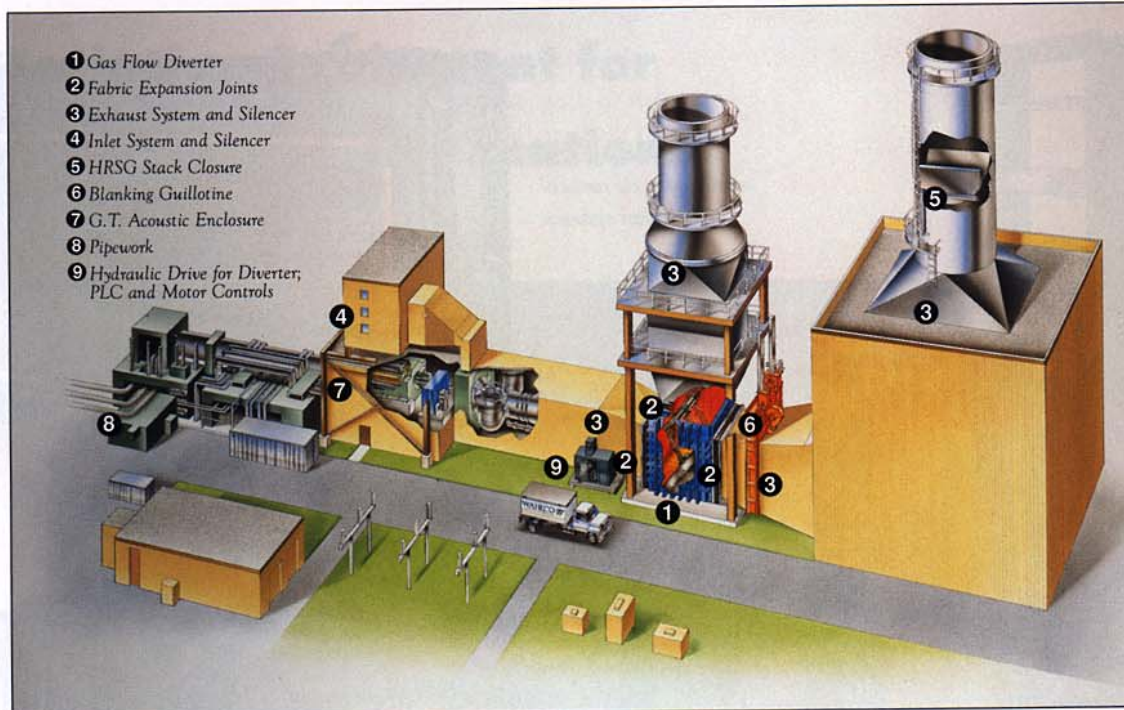


GTEJ-3: Hot Frame to Hot Frame

Three Models for Three Thermal Transitions

All combinations of internally and externally insulated components can be joined by our three models: GTEJ 1 for Cold Frame to Cold Frame, GTEJ-2 for Hot Frame to Cold Frame, (or Cold Frame to Hot Frame), and GTEJ-3 for Hot Frame to Hot Frame.

Complete Bypass Systems



WahlcoMetroflex can engineer and provide all components required for a complete bypass system.

Local Fabrication, Erection and Start-Up Service

WahlcoMetroflex can fabricate in its own shops or locally to help meet local content requirements. As the largest damper company in the world, we can also provide unparalleled field assistance. WahlcoMetroflex personnel operate worldwide to assure fast response to customer needs.

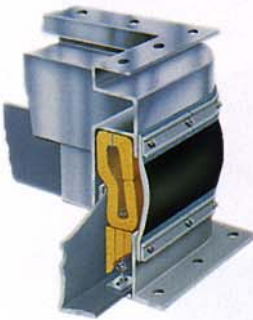
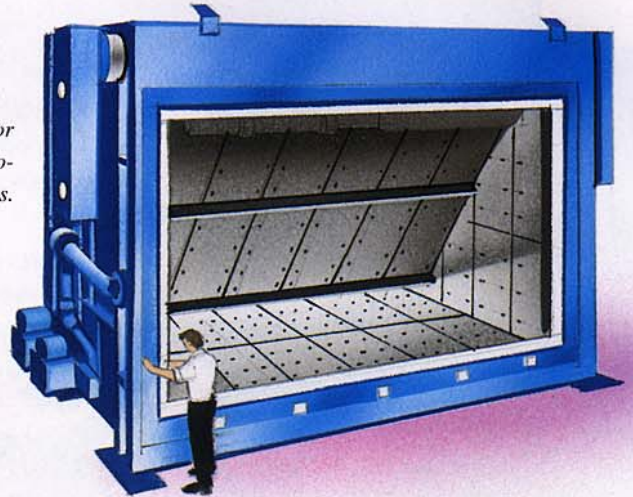


Additional Gas Flow Control Products

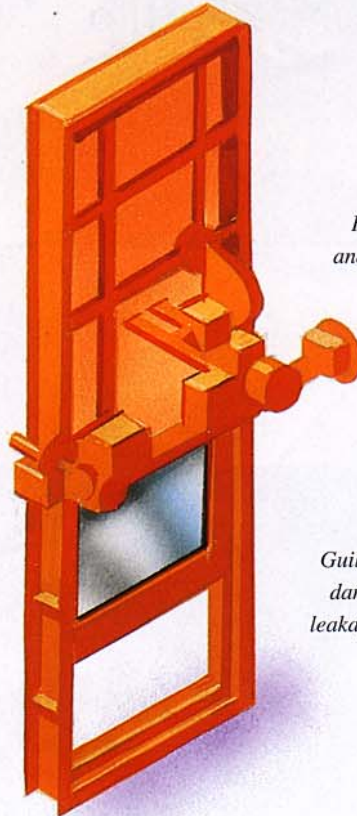


Multi-louver damper for control and tight shut off application.

Diverter damper for combined cycle and co-generation systems.

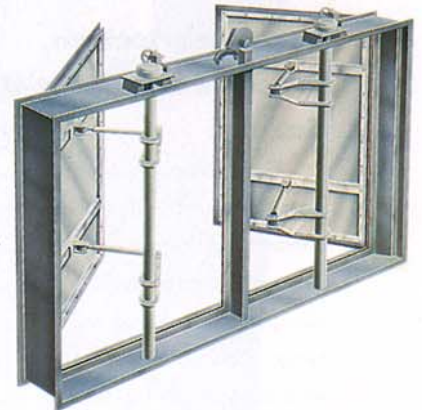


WahlcoMetroflex's fabric expansion joints are designed for applications over 2000°F (1100°C).



Guillotine and flap dampers for zero leakage applications.

Rolled bellows for control of expansion and contraction in high temperature/high pressure piping.



WahlcoMetroflex, Inc.

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