GUIDE FOR ENGINEERINGS AND END USERS

HOW TO SPECIFY GRAPHITE HEATER OR COOLER FOR CHEMICAL PROCESSES APPLICATIONS

Graphite Technology

Rev 04

INTRODUCTION

Graphite Technology is a group of companies specialized in the design and manufacture high quality equipment made of graphite or fluoroplastics for chemical processes industries. Graphite Technology is the only company in the world to propose real graphite with PTFE impregnation at high pressure (GT-FLON and GT-TOYO FLON). Graphite with real PTFE impregnation is the only reliable material of construction of heat exchangers for stainless steel and alloy pickling baths liquors (very oxidative media).

The know-how of graphite equipment enables to improves reliability of customer's plant operating heat exchangers made of graphite material.

Our experience showed that ;

- 85% of incident occurring on graphite equipment are coming from peripheral equipment or mistake during installation and maintenance which bring overstress on graphite parts.
- Most of short life time of equipment is due to design mistake at early stage of project. These mistakes are mainly due to lack of knowledge from person in charge of technical specifications for graphite equipment.

This is the aim of this document, helping engineering companies and end users to specify correctly the heat exchanger to insure reliable operations.

Contact us for more details and to study how we can expertise your installation.

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1. Chemical processes applications

Graphite heat exchangers are used since decades for chemical processes for heating or cooling of very corrosives media.

Many companies are using graphite equipment without any issues for years. Users having issues are operating equipment which is not designed properly. Graphite equipment stays the best choice for highest corrosive media. The return on investment is much faster than Tantalum or Silicone Carbide equipment. Maintenance cost can be reduced significantly by following some basic rules for the design of the equipment.

The lifetime of graphite components for heat exchangers are related to 5 mains parameters. By addressing these 5 parameters you can insure life time of more than 10 years.

1.1. Corrosion resistance.

For "mild corrosion", graphite impregnated with phenolic resin sintered at temperature > 170 °C (338°F) insure efficient corrosion resistance against most acids and mainly hydrochloric acid or sulfuric acid.

For "extreme corrosion", graphite impregnated with PTFE resin sintered at high temperature > 330°C (626°F) insure efficient corrosion resistance.

Phenolic resin is quickly corroded by nitric acid, hydrofluoric acid and peroxide and is to avoid with such processes.

PTFE resin impregnation "**non sintered**" or PTFE coating have a lifetime 10 times lower than PTFE sintered resin impregnation at same operating conditions.

The lifetime against corrosion is related to the hot side temperature of the heat exchanger.

With time, corrosion will open porosity in the graphite and allow communication between steam or cooling water and corrosive media. End user may sometimes not notice this problem immediately if the equipment is not often stopped. If the steam pressure is higher than the corrosive media pressure in the heat exchanger, this corrosion will lead to penetration of steam inside the process side which is a minor problem without corrosion issues.

During shut down period, without pressure on service side, the corrosive media will migrate on the shell side. The steel shell will be corroded and the condensate piping will contain more and more acid with corrosion process.

Consult us for the selection of grade based on the corrosive media temperature and composition.

1.2. Erosion resistance.

If circulating media contains hard particle it may erode the graphite elements and reduce life time.

For such case GT propose a special inlet design to resist erosion. C-HARD© design is an option on our equipment with high erosion risk.
Erosion can be avoided if the velocity on process side remains at a low value which needs to be specified.

1.3. Cleaning frequency.

Dismantle and cleaning of graphite is risk of damage. To reduce frequency of such process, velocity must be adapted to the circulation pump flow and the dismantle and cleaning should be done by experienced people.

Minimum velocity of 1 m/s insure that fouling process is slow. Maximum velocity of 1.5-2.0m/s (if equipment without erosion protection) insure protection against erosion.

The ligament is the thickness of graphite between process side and service side. Ligament of graphite between service and process side must be thicker in case of very dirty process which will require cleaning using drill bit or mechanical ways. For relatively clean process, ligament of 3.5mm (1/7 inch) is a safe option (except if high pressure design is required). For dirty process, ligament of 5.5mm (2/9 inch) is a wise choice.

1.4. Thermal cycling.

Some processes are using the same equipment for heating and cooling the pickling bath. Graphite components see alternatively hot steam or cold water. This is a risk to create a thermal shock in graphite components. Ligament thickness, density of graphite and level of phenolic resin are important parameters to prevent early failures.

1.5. Water/steam hammering/mechanical stress

User installation face often problem due to steam or water hammer (see our guide GUIDE FOR MAINTENANCE AND ENGINEERING TEAMS, PREVENTION OF WATER AND STEAM HAMMER, PIPE EROSION, PROTECTION OF GRAPHITE CHEMICAL EQUIPMENT for more information). These events may create surge of pressure which will reduce the lifetime of standard graphite components.

To avoid such problem, it is possible to adopt reinforced design of blocks and thick ligament. This ligament withstands the differential of pressure between process and service side.

Drilling of blocks using CNC machine insure higher mechanical strength due to tight distribution of ligament thickness.

It is also recommended to request thick ligament (>=3.5mm) and reinforced design of blocks (drilling pattern with reinforcement) if the pressure on service side is more than 6 barg (87 PSIG).

Graphite Technology propose as world exclusivity HAMMER PROOF device which will protect the equipment from surge of pressure. This device is installed in standard on some of our equipment and it could be installed as stand-alone device on existing piping network to protect all types of equipment.

1.6. Parameters to specify in your inquiries

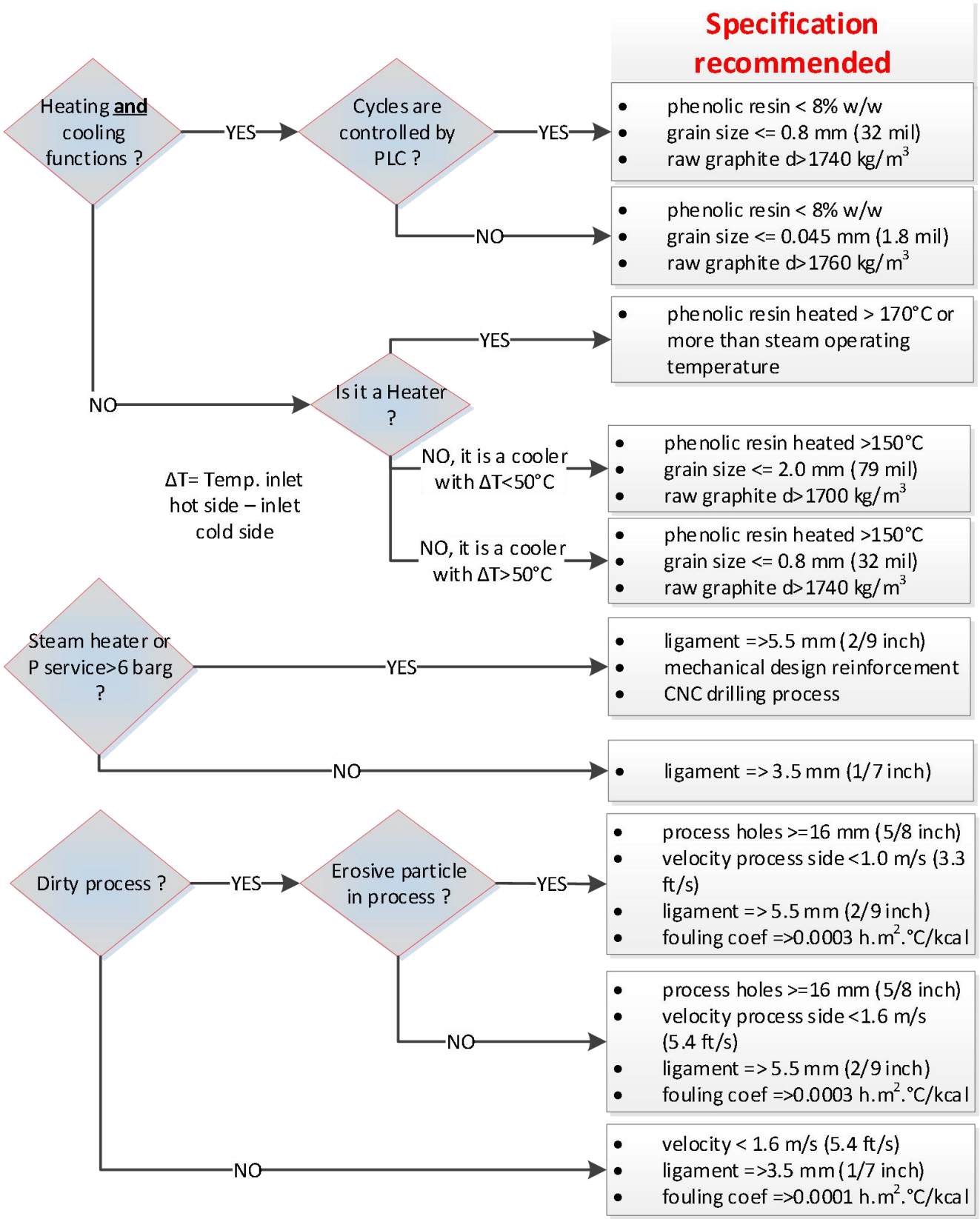
The specifications of the equipment could be summarized as follow.

Parameters to specify	Remarks	To use with equipment		
		Block	Tubes	Cubic, plate, disc
Raw graphite density	Protection against thermal shock, corrosion	yes	yes	yes
Raw graphite grain size	Protection against thermal shock, corrosion	yes	yes	yes
Ligament thickness	Protection against pressures fluctuations and frequent mechanical cleaning	yes	yes	yes
Type of impregnated resin	Protection against corrosion	yes	yes	yes
Pattern of holes drilling	Protection against pressures fluctuations	yes	no	no
Heating temperature of resin	Protection against corrosion and aging of resin	yes	yes	yes
Content of phenolic resin into raw graphite	Protection against thermal shock	yes	yes	yes
Maxi velocity into holes/channel	Important if particle in media	yes	yes	yes
Fouling coefficient	Important if dirty process	yes	yes	yes
Min diameter of holes, section of channel	Important if dirty process	yes	yes	yes
CNC holes drilling	Protection against pressures fluctuations	yes	no	yes

The values to specify could be found in the following pages according to a flow chart of simple questions.

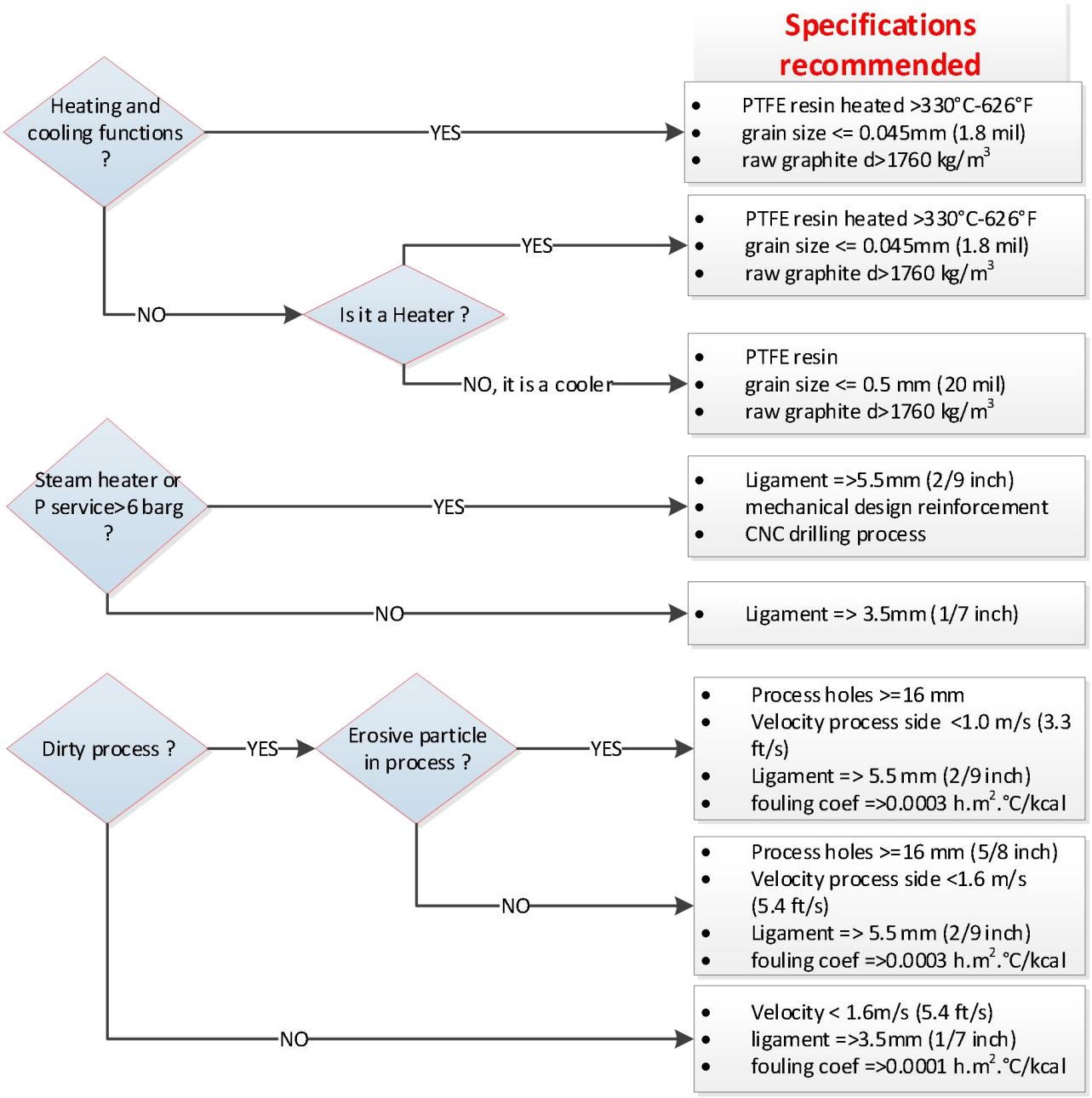
2. Chemical processes compatibles with phenolic resin

Consult us for corrosion resistance compatibility guidance.


Specification recommended
Heating and cooling functions ?
YES
Cycles are controlled by PLC ?
YES
phenolic resin < 8% w/w
grain size <= 0.8 mm (32 mil)
raw graphite d>1740 kg/m3
NO
phenolic resin < 8% w/w
grain size <= 0.045 mm (1.8 mil)
raw graphite d>1760 kg/m3
NO
Is it a Heater ?
YES
phenolic resin heated > 170°C or more than steam operating temperature
NO, it is a cooler with ΔT<50°C
phenolic resin heated >150°C
grain size <= 2.0 mm (79 mil)
raw graphite d>1700 kg/m3
ΔT= Temp. inlet hot side – inlet cold side
NO, it is a cooler with ΔT>50°C
phenolic resin heated >150°C
grain size <= 0.8 mm (32 mil)
raw graphite d>1740 kg/m3
Steam heater or P service>6 barg ?
YES
ligament =>5.5 mm (2/9 inch)
mechanical design reinforcement
CNC drilling process
NO
ligament => 3.5 mm (1/7 inch)
Dirty process ?
YES
Erosive particle in process ?
YES
process holes >=16 mm (5/8 inch)
velocity process side<1.0 m/s (3.3 ft/s)
ligament => 5.5 mm (2/9 inch)
fouling coef =>0.0003 h.m2.°C/kcal
NO
process holes >=16 mm (5/8 inch)
velocity process side<1.6 m/s (5.4 ft/s)
ligament => 5.5 mm (2/9 inch)
fouling coef =>0.0003 h.m2.°C/kcal
NO
velocity < 1.6 m/s (5.4 ft/s)
ligament =>3.5 mm (1/7 inch)
fouling coef =>0.0001 h.m2.°C/kcal

3. Highest corrosive chemical processes (oxidative media)

Such process is not compatible with phenolic resin impregnation. Consult us for corrosion resistance compatibility guidance.

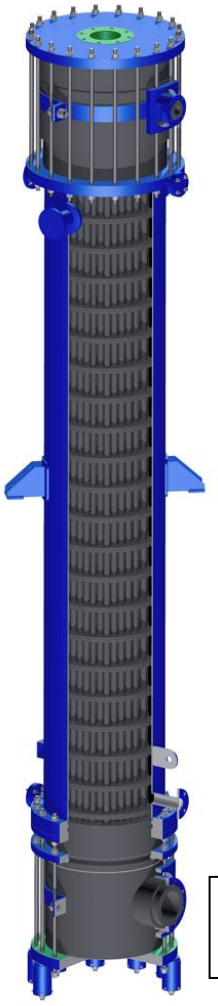


4. Type of heat exchangers to select

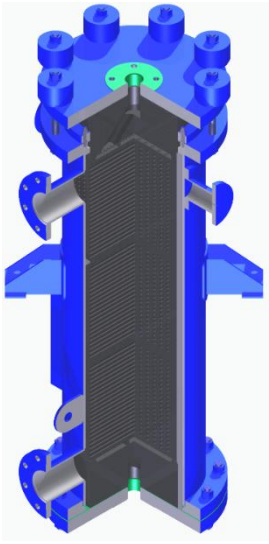
Hereunder, a selection guide of models of heat exchangers more adapted for your process based on few operating parameters.

Type	Dirty process	Flow >500-700 m3/h	Oxidative media (3)	Low footprint	Low LMTD(2)
Block	YES	NO	YES	YES/NO	NO
Cubic	YES	NO	YES	YES	NO
Plate	NO	NO	YES	YES	YES
Shell & tube	YES	YES	NO	NO	NO
Disc	YES	NO	YES(1)	YES	YES

(1) only if discs with gasket, not cemented with phenolic glue
(2) LMTD – logarithmic mean temperature difference between 2 sides media
(3) Sulfuric acid >85%, nitric acid, peroxide,…

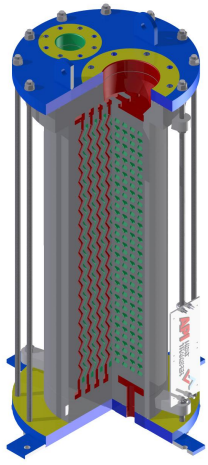


Shell & tube

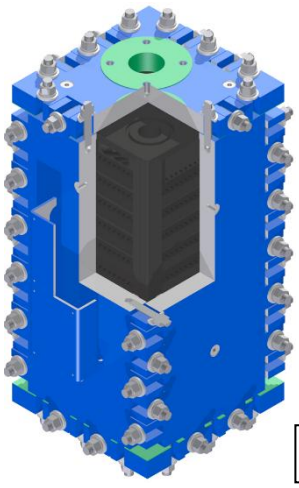


Block

Plate



Disc



Cubic

5. Quick check list for installation/inspection of graphite equipment

Question	Yes	No
Equipment use steam for heating ?	Check valve opening speed to avoid thermal shock or steam hammer. Insure good condensate draining. Insure that the condensate line has slope to evacuate condensate	
Does steel flange of equipment are corroded ?	Check that rust does not block motion of shell floating flange. Check that rust does not block motion of spring system. Identify origin of acid leak to prevent rust impact on equipment mechanical working.	
Does expansion bellow is installed on each graphite nozzle ?	Check that expansion/ compression of bellow is not blocked by nut position (misinstallation).	Install expansion below or adopt STRESS FREE© design from GT.
Does piping line have a fixed point close to the nozzle connection ?	Check that expansion of the equipment steel shell will not create shear or compression between graphite nozzle and fixed piping.	Install expansion joint between equipment and piping or adopt STRESS FREE© design from GT.
For heat exchanger, does temperature between hot and cold side is more than 50°C /122°F ?	Check that operation team respect sequence of fluid use (cold first, hot second) to avoid thermal shock.	
Does equipment can be fully drainable ? No zone which can keep liquid after drain.		Insure that liquid cannot freeze inside equipment during stand by period.
Equipment has a system to measure spring compression value ?	Measure compression of spring when equipment is cold and compare it with manufacturer data's. Insure that compression is same for all springs.	
Equipment has spring compression system ?	Check that compression of all springs is similar.	

6. Trouble guide of graphite equipment

Issue	Possible cause	Solution
Steam/water hammering (noise evidence)	Condensate line not well drained Steam valve opening/closing too fast Pump shut down	Use reinforced block design SHOCK PROTECT®, use our device HAMMER PROOF® on piping. Modify piping installation and instrumentation. Adopt HAMMER PROOF devices.
Thermal shock break graphite	At startup, sequence of media introduction creates thermal shock. Steam temperature too high.	Use PTFE or carbon impregnation graphite grade (GT FLON/GT CARB) instead of phenolic impregnation. Adopt fine grain graphite (<0.04mm) to improve thermal shock resistance.
Corrosion with phenolic impregnated graphite	Strong oxidant in process fluid. Resin not well stabilized.	Use PTFE or carbon impregnation (GT FLON / GT CARB). Use fine or GT TOYO TANSO ultrafine grain graphite (consult us).
Nozzle break	Expansion bellow not well installed or designed. Stress on gasket area too high. Thermal shock. Corrosion of graphite material. Flange corrosion sinter graphite nozzle which create stress.	Check bellow settings Choose STRESS FREE® design. Header without graphite nozzle Use PTFE or carbon impregnation graphite grade (GT FLON/GT CARB) instead of phenolic impregnation.
Erosion of blocks/tubesheet	Velocity too high (maxi 1,5-1,8 m/s 5.9 ft/s with liquid). Hard particle in fluid. Some process holes plugged. Corrosion of graphite and/or resin	Add C-HARD© "hard" entrance plate. Review design. Adopt FILT-IN©, filter before fluid inlet Unplug holes to reduce velocity. Measure graphite hardness to identify corrosion.
Fouling	Many causes. complex phenomenon Velocity too low sometimes (wrong design).	Choose GT FLON, PTFE impregnated grade Adapt block design to optimize velocity

Issue	Possible cause	Solution
Lost efficiency	Fouling. Service by-pass. Change of flow parameters in the process.	To study with customer. Will depend the cause.
Gasket leakage	Hammering and gasket slip. Gasket stress too low. Creeping of gasket which requires retightening. Gasket corroded or broken. Compression spring malfunction.	Inspect gaskets. Use of expanded PTFE gaskets with GT sealing design. Adopt STABLE LOAD® spring system.
Block / header cracked or leak	Hammering, equipment overtight, corrosion, overstress from piping, mechanical shock or hurt (during holes cleaning operation), erosion, frost damage (equipment not drained in winter).	Use reinforced block design SHOCK PROTECT® Adopt STABLE LOAD® spring system or HAMMER PROOF® device Adopt STRESS FREE® design. Expertise with customer to solve issue.
Reduced heat transfer performance	Fouling Service side baffle bypass	Clean graphite (mechanically, chemically). See page 12 Inspect baffle.
Hydraulic test pressure going down without leakage find	Slow migration of water into gasket groove. Slow migration of water into closed porosity of graphite Air pocket trapped into equipment.	Fill equipment with water under vacuum Apply pneumatic test (at low pressure) to check if pressure go down also. Remove air pocket by applying vacuum prior to introduce water or to remove air.