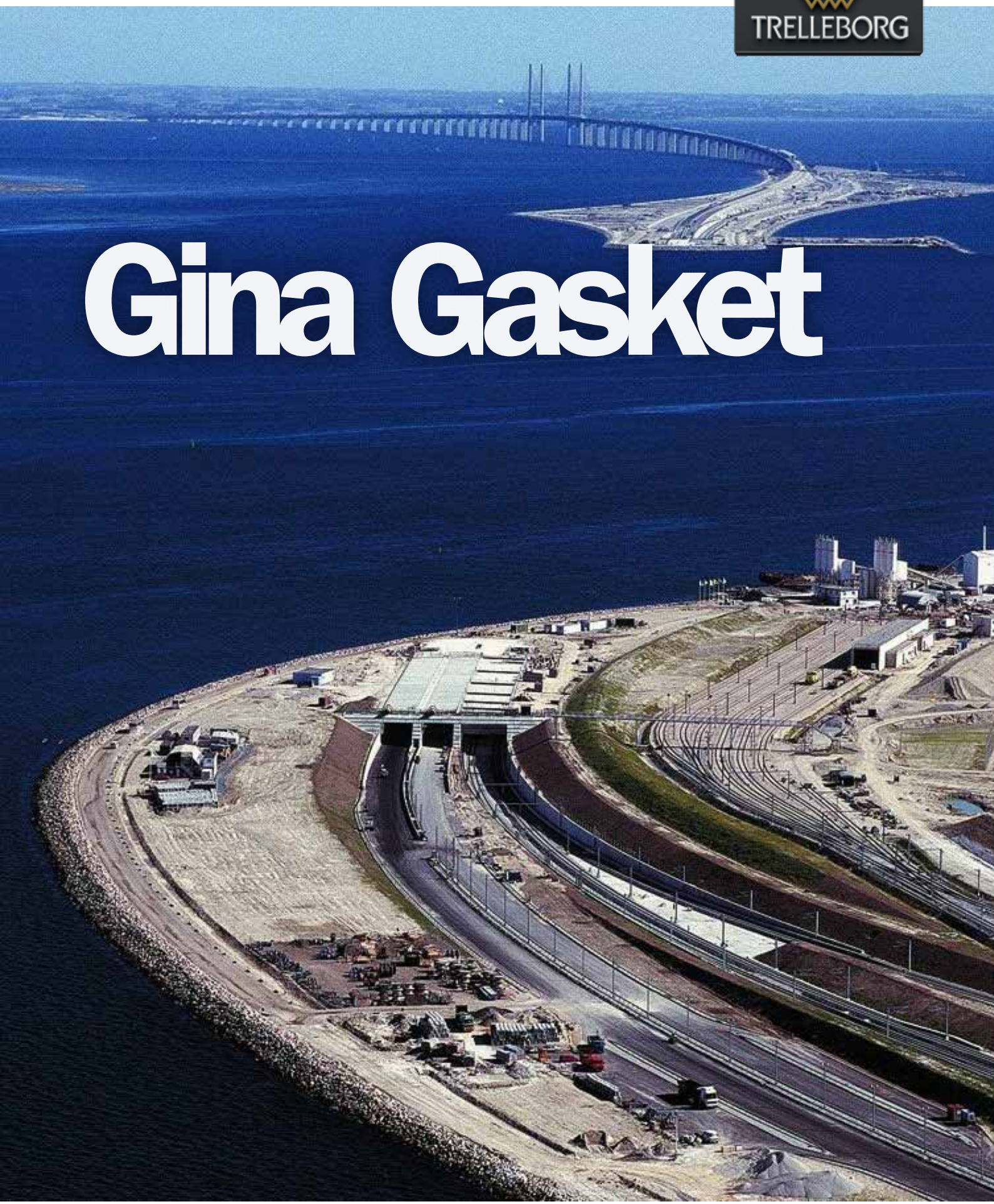
TRELLEBORG

Gina Gasket



Introduction

The Gina gasket and Omega seal are used between the sectional elements of immersed tunnels to prevent water ingress due to external water pressure.

This combination of seals not only allows for sealing but also for the transfer of the hydrostatic loads and movements between the tunnel ends due to soil settlement, creep of concrete, temperature effects and if required earthquakes.

The designs are generally based on the expected tunnel lifetime of 100 years.

Trelleborg is the specialist in the design of Gina gaskets and Omega seals. Trelleborg not only supplies these seals, but upon request also offers site assistance during installation.

Since the early sixties Trelleborg has supplied a large number of seals for immersed traffic, cooling water, pipeline and cable tunnels in many countries all over the world.

This brochure provides technical information for the use and installation of the Gina gasket.

Casting basin with tunnel elements - Piet Hein tunnel

Applications of the GINA gasket

An immersed tunnel is normally constructed from structural concrete elements approximately 100-150 meters long, which are manufactured in a casting basin or dry dock.

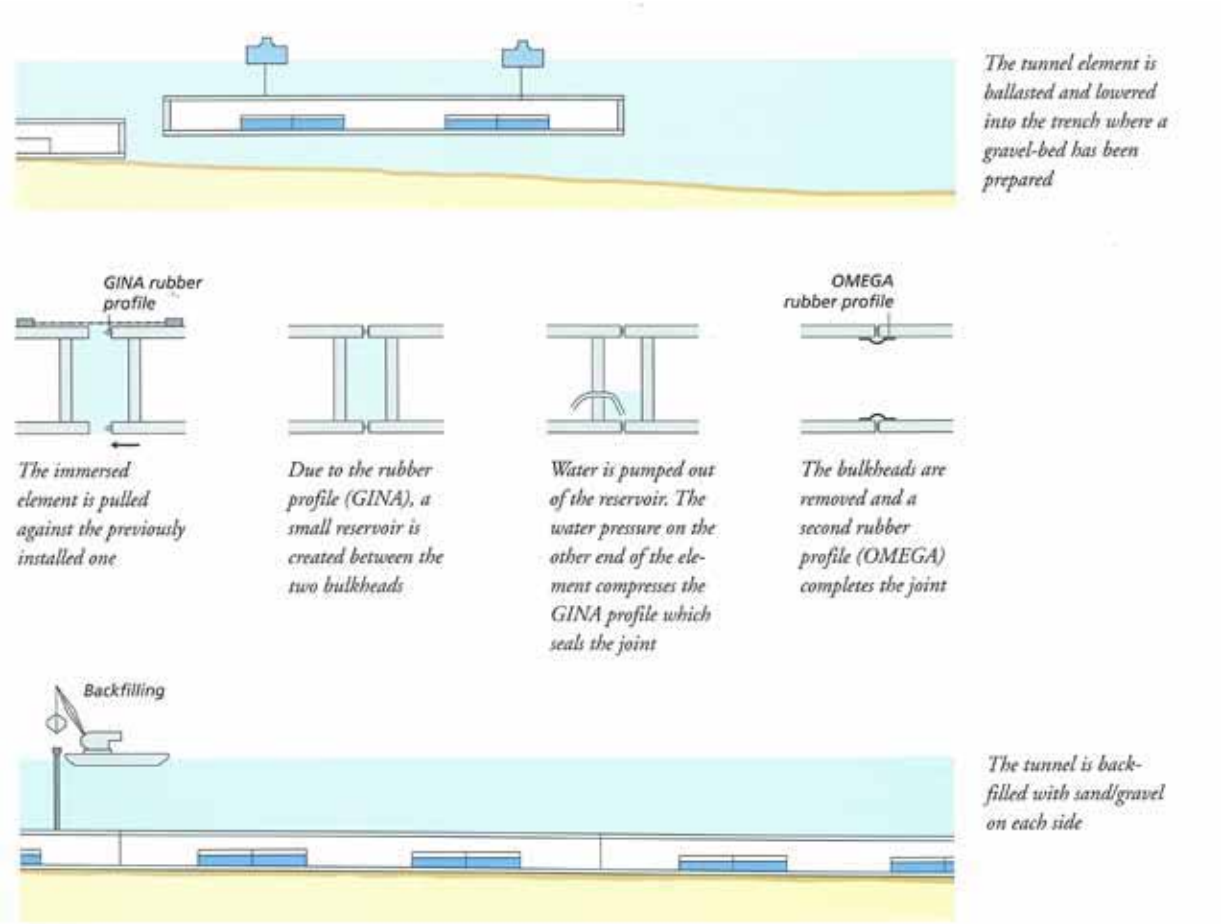
The tunnel elements are provided with temporary bulkheads at both ends to ensure that the element is watertight and capable of floating. On one end of each tunnel element, an endless Gina gasket is mounted. When manufacturing of the tunnel elements is completed, the dock is flooded and the elements floated.

Each element is towed to its final position and then immersed. The immersed tunnel element is then pulled firmly up against the preceding immersed element with hydraulic jacks.

The initial contact of the Gina should be accomplished using a low pulling force. When the Gina has full contact around the total circumference of the adjacent element, the water between the bulkheads is pumped out.

Due to pressure differential between the bulkheads and the hydrostatic pressure on the outside of the tunnel, the Gina profile compresses and seals the joint.

A secondary seal, the so called omega seal, is then clamped across the joint on the inside of the tunnel. In general the bulkheads are removed after approval of the pressure test between the Gina and Omega.



Design philosophy

This chapter presents the design philosophy for Gina gaskets. In order to select a Gina profile the following technical information is required:

- number of joints
- cross section size of steel mounting frames
- lengths of tunnel elements
- water depth at each joint
- tide variations
- specific weight of water
- all movements and gap variations of the joint in axial and lateral directions
- specific conditions for installation

In general Trelleborg is requested to assist in product selection.

Design specification

The supplier of the Gina gasket needs to show by calculations based on the measured force-compression curves that at all design water pressures, the selected Gina gasket satisfies following conditions within agreed safety limits:

1. transfer of the hydrostatic loads at high water level within the maximum compression capacity of the Gina profile;
2. sealing at all water levels for all joints, including the effect of gap variations due to variation in smoothness/flatness of the tunnel faces, rotation of immersed tunnel elements, creep and shrinkage of the concrete material and temperature effects;
3. calculation of the restoring moments to re-align misalignment of a tunnel element;
4. calculation of the proper functioning of the Gina gasket after re-alignment with respect to prevention of leakage at the gap opening side and prevention of overload at the gap closing side;
5. above mentioned sealing properties should incorporate the effect of relaxation on the rubber material of the seal over the tunnel life time period;
6. the Gina flange construction should be able to withstand additional loads without dislocation, due to shear of the compressed Gina gasket in case of differential tunnel settlement.

Safety against leakage

The supplier should show by calculations, that during the total lifetime of the tunnel, the contact pressure between the Gina and tunnel face is sufficiently larger than the outside water pressure.

Clamping system

The supplier should present calculations for the steel clamping system to show that all stresses and strains of steel clamps and bolts are within specified limits.

Expected tunnel lifetime

For the expected tunnel lifetime period, often at least 100 years, the supplier should show the correct functioning of the Gina gasket system even at the end of this period, by incorporation of the effect of relaxation on the sealing properties.

In general Trelleborg is requested to assist in product selection.

Materials

The Gina gasket is to be manufactured from a blend of SBR and NR rubber. This material should satisfy the material specifications, as valid at the time of production in the Trelleborg materials programme.

Lifetime of materials

The supplier should show by material tests that the expected material lifetime of the rubber seal exceeds the tunnel lifetime by a considerable margin.

Storage

Supplier should present storage instructions according to the international standard ISO 2230.

Installation maual

The supplier should provide an installation manual to ensure proper installation of the Gina seal.

Quality assurance and control

During all facets of the production, all processes are monitored, checked and recorded in a Quality Plan according to Quality System Certification ISO9001 and Environmental System Certification ISO14001.

The monitored processes including mixing of the rubber compound, production fo the seal, vulcanisation of the straight and curved parts and the final fabrication stage when all elements are combined into the final seal.

Every seal is provided with a Material Certification and a Dimensional Cerficiation, issues by the Quality Department of Trelleborg.

References

The supplier should verify and demonstrate their capability to design and manufacture the required type of Gina seals by references for comparable tunnel projects.

Product Range

Trelleborg Ridderkerk currently has 3 standard types of Gina gaskets, see table below.

Table: Standard range of Gina type

Type	Drawing	Standard Radius (mm)	Standard corners (degrees)	Weight (kg/m)
ETS-130-160	AA4-96-4317	400	90 & 135	18.3
ETS-180-220	AA4-96-4318	500	90 & 135	34.9
ETS-200-260 SN	AA4-96-4183 B	500	90 & 135	42.4

The gaskets are vulcanised in straight lengths to a max. of 12 m. Corner pieces are vulcanised to the required radius and/or angle. Each type of Gina gasket has a standard bending radius.

Radii other than the standard radii are possible, but are less economic. The total gasket is constructed from selected straight and curved elements by vulcanising the joints.

Besides these standard types Trelleborg has the capability to design and manufacture custom made solutions.

The selected rubber compound is normally a blend of NR (natural rubber) and SBR (styrenebutadiene rubber). The blend combines excellent mechanical properties with low water absorption and good resistance against chemical and bacteriological attack.

The selected rubber should match the required lifetime of the tunnel. The low values for relaxation, i.e. decrease in reaction force at constant deformation, of our compound, provides a desirable long-term behaviour of the sealing system.

Clamping System

The gaskets are mounted on the ends tunnel using bolted clamping strips.

A typical design of the clamping system is given in appendix 6 for ETS 130-160 and in appendix 7 for ETS 180-220 and 200- 260 SN.

By request, we are able verify the dimensions of the clamping system for specific cases.

Top corner of mounted Gina frame – Oresund tunnel

Storage, transport & installation

During storage it is important to prevent damage such as ozone cracking. Products damage may also occur during transport or unpacking. Trelleborg therefore is able to provide storage and transport procedures, which are based on an ISO specification.

In general a specially constructed hoisting beam is used to lift the Gina gasket into place. The gasket should be hung from the hoisting beam by a large number of nylon slings. Extra protection caps may also be required to prevent damage to the relative soft nose section of the Gina profile.

The hoisting operation should be executed very carefully to prevent local damage and overloading of the seal due to its own weight. Trelleborg is able to provide an installation procedure and guidelines to ensure correct installation. Upon request, supervision of the installation may be carried out by a Trelleborg Ridderkerk specialist.

Hoisting of Gina frame – Oresund tunnel

Policy quality, environment, safety and health

The policy of Trelleborg Bakker BV is to design, produce and deliver rubber products which are in accordance with the customers' requests, needs and expectations.

The starting point of our policy is the Trelleborg Group policy statement 'Code of Conduct' on our website www.trelleborg.com.

During the development of products and processes the environment, safety and health are integral to the process.

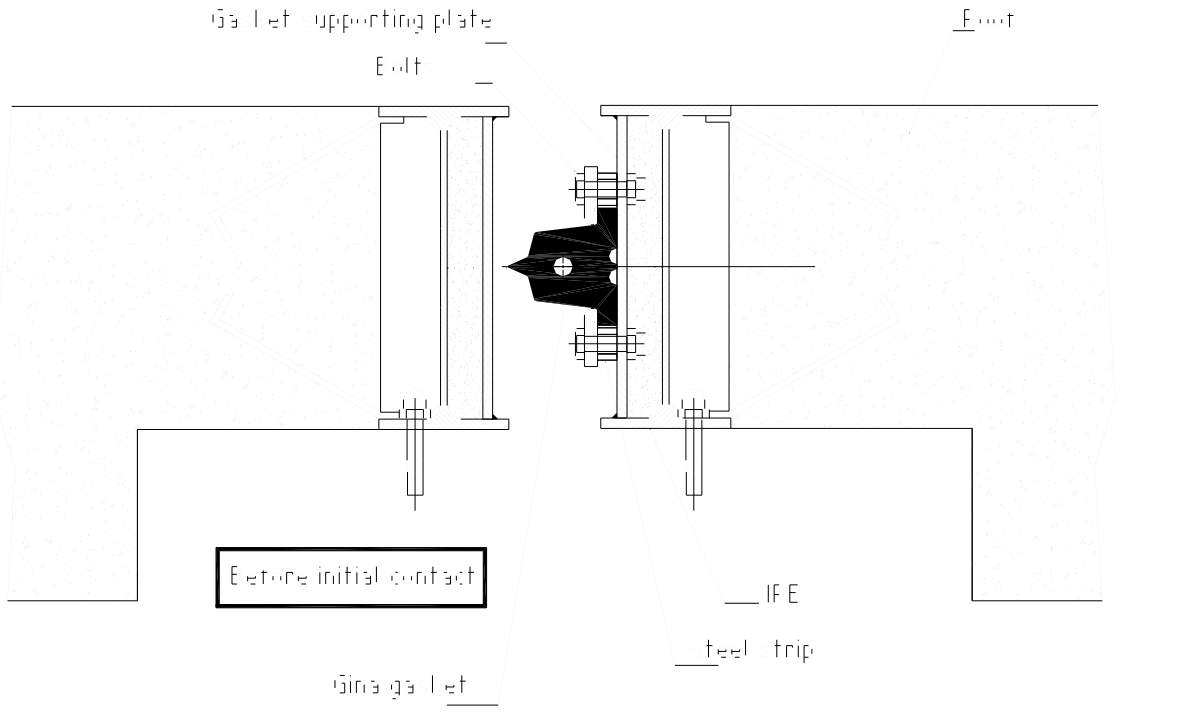
Trelleborg is using an integrated management system which complies to international standards such as ISO 9001, ISO 14001 and SCC**.

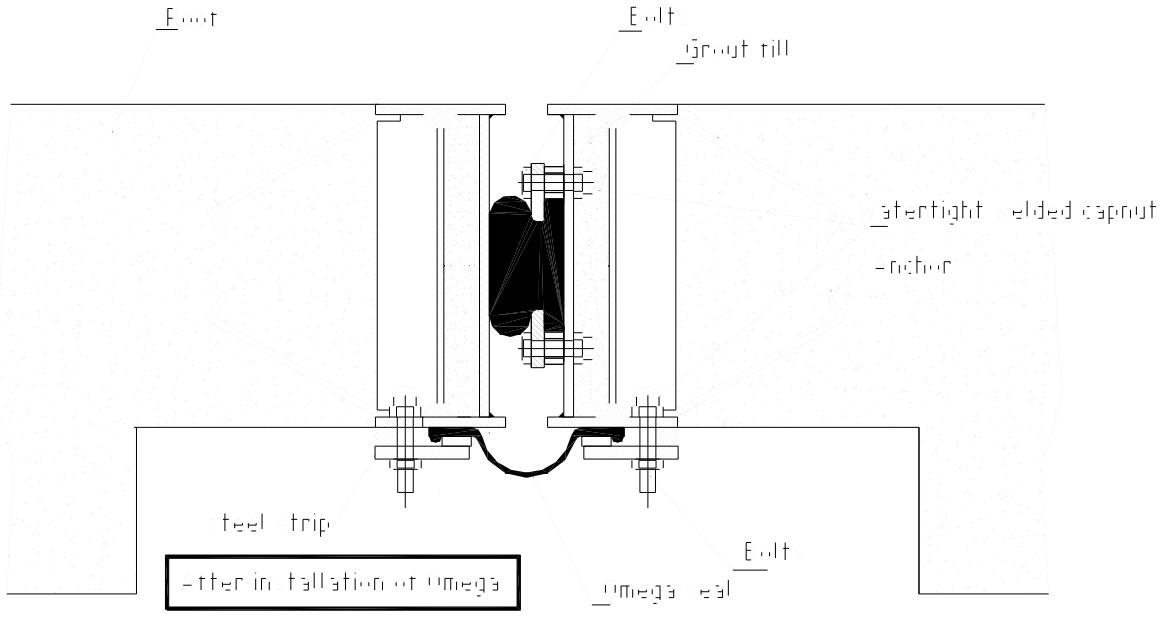
Appendix 1. Reference list Gina profiles

Project	Location
Barrage Bou	Algeria
Kennedy Tunnel	Belgium
Rupel Tunnel	Belgium
Barrage de L'eau d'Heure	Belgium
Liefkenshoektunnel	Belgium
Welland Tunnel	Canada
Guangzhou Tunnel	China
Ningbo Tunnel	China
Changhong Tunnel	China
Taihe Road Tunnel	China
Lim Fjord Tunnel	Denmark
Gulborgsund Tunnel	Denmark
Oresund Tunnel	Denmark-Sweden
Tunnel Marseille	France
Bastia Tunnel	France
Meteor Tunnel	France
Elbe Tunnel	Germany
Minden Tunnel	Germany
Kernkraftwerk Isar	Tunnel
Kernkraftwerk Emsland	Germany
Kernkfraftwerk Neckar	Germany
Schwedeck Sea Remova	Germany
Warnowquerung Tunnel	Germany
Aktio Preveza	Greece
Massed Transitunnel	Hong Kong
Advance Tunnel	Hong Kong
Cooling Water Tunnel NPW	Iran
Bakar Tunnel	Iran
Cork Tunnel	Ireland
Keihin Tunnel	Japan
Nippon Kokan Tunnel	Japan
Underground	Netherlands
Coentunnel	Netherlands
IJ-Tunnel	Netherlands
Hemspoortunnel	Netherlands
Kiltunnel	Netherlands
Vlaketunnel	Netherlands
Heinenoordtunnel	Netherlands
Drechtunnel	Netherlands
Beneluxtunnel	Netherlands
Tunnel for pipes	Netherlands
Spijkenisse Tunnel	Netherlands
Buiten-IJ-Tunnel	Netherlands
Wilemsspoortunnel	Netherlands
Aquaduct Grouw	Netherlands

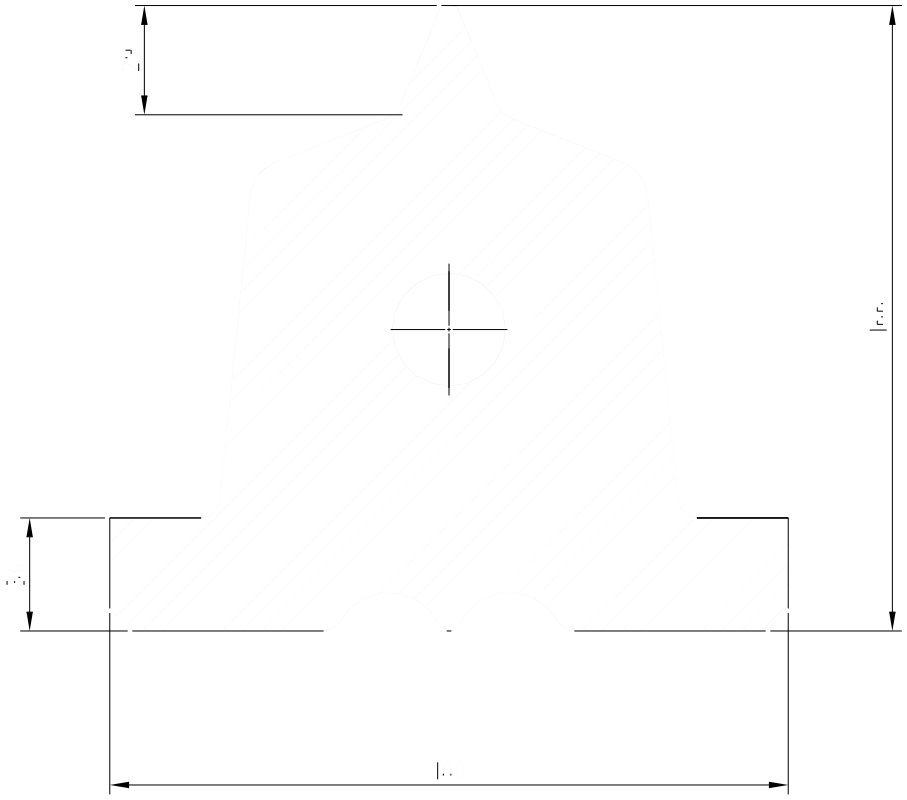
Project	Location
Aquaducht Gaag	Netherlands
Schipholteunnel	Netherlands
Coolhaventunnel	Netherlands
Tunnel de Noord	Netherlands
Wijkertunnel	Netherlands
Piet Heintunnel	Netherlands
Second Beneluxtunnel	Netherlands
Calandtunnel	Netherlands
HSL Tunnel Oude Maas	Netherlands
HSL Tunnel Dordtse Kil	Netherlands
AL-Koh-Bar Tunnel	Saudi Arabia
Pulau Seraya Tunnel	Singapore
Tuas Bay Tunnel	Singapore
Metro Bilbao	Spain
Koahsiung Cross-harbour Tunnel	Taiwan
Cooling water tunnel Common Peel	United Kingdom
Conway Tunnel	United Kingdom
Medway Tunnel	United Kingdom
Boston Harbour Tunnel	USA
Fort Point Tunnel	USA
South Boston Piers Transitway	USA
Tunnel Leningrad	Russia

Appendix 2. Reference list GINA profiles

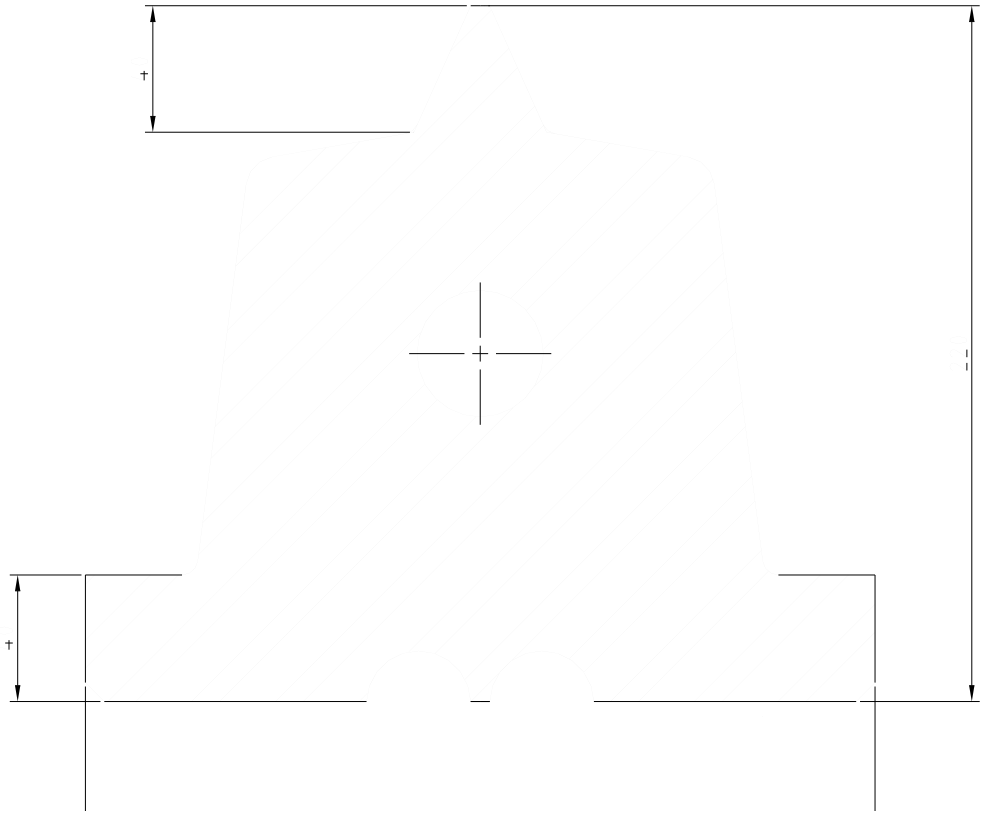




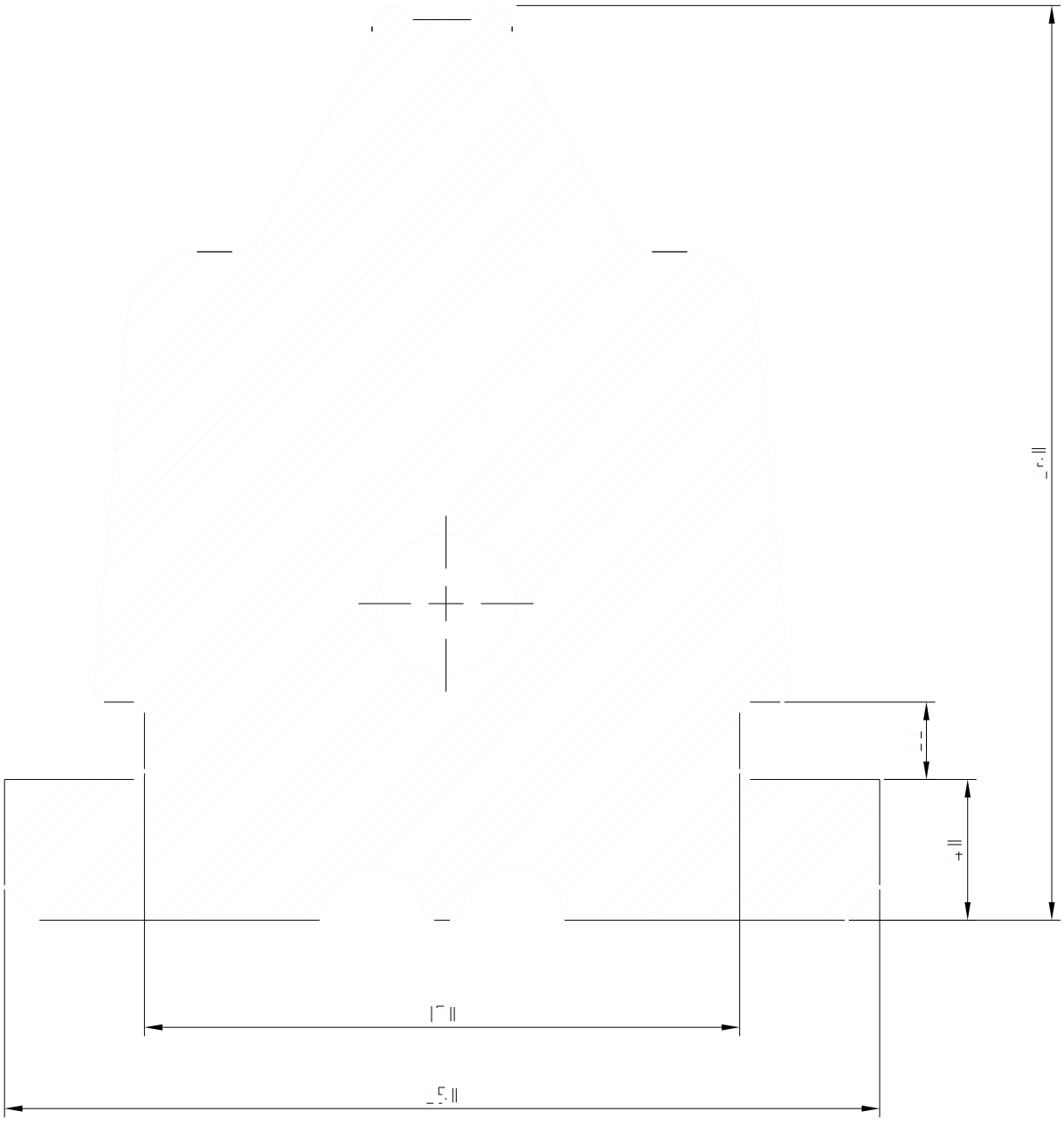
Appendix 3. GINA-profile: ETS 130-160



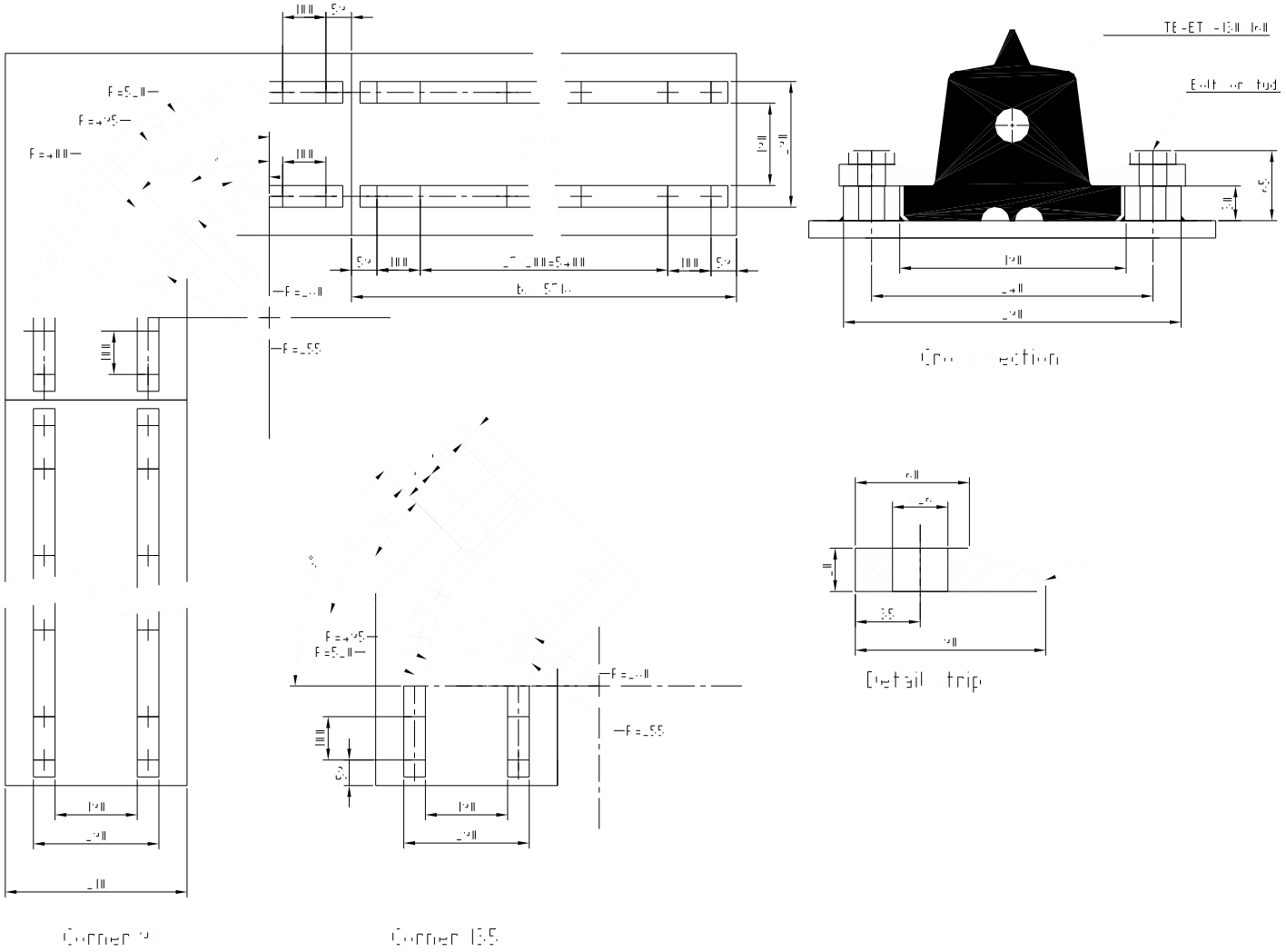
Appendix 4. GINA-profile: ETS 180-220



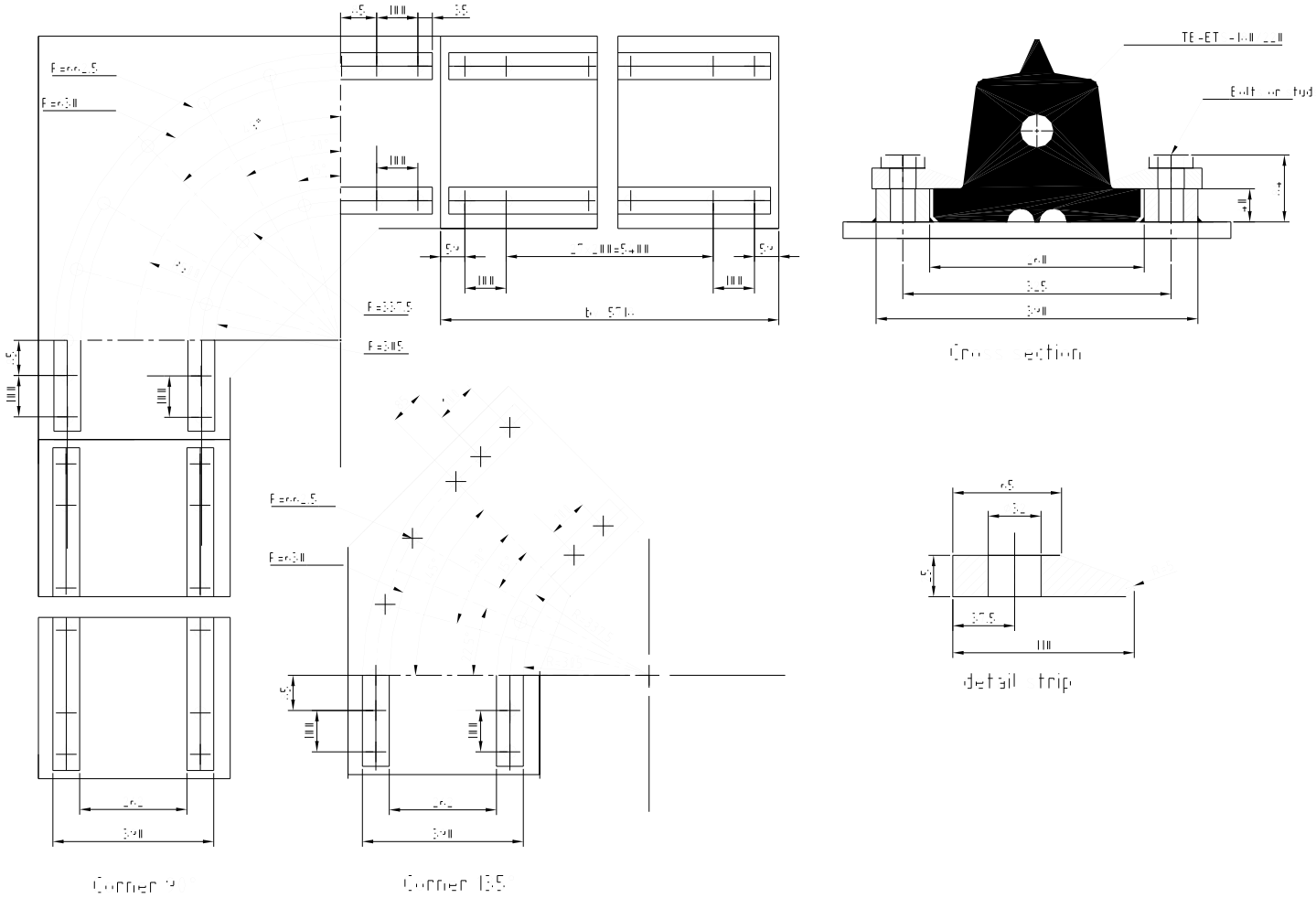
Appendix 5. GINA-profile: ETS 200-260-SN



Appendix 6. Typical clamping system ETS 130-160



Appendix 7. Typical clamping system ETS 180-200 & ETS 200-260 SN



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linkedin.com/company/trelleborg

Trelleborg Engineered Products Australia Pty Ltd, Brisbane Head Office, 515 Zillmere Rd, Zillmere, Queensland, Australia 4034
Tel: +61 7 3866 7444 Fax: +61 7 3263 4912

Perth Office, 25 Glassford Rd, Kewdale, Western Australia, Australia 6105
Tel: +61 8 9256 6000 Fax: +61 8 9353 5990