MACSTEEL VRN

HIGH STRENGTH AND HARD WEARING
STEEL SPECIALISTS

Catalogue

The MACSTEEL VRN Group of Companies

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PROFILE CUTTING SERVICE WHY USE PROFILE PLANTS

As part of the MACSTEEL VRN services, all metals can be accurately cut-to-size and shape, using the latest computer controlled profile cutting technology.

Many companies still do their own profile cutting mainly because they do not trust steel service centres, or because they feel they are too expensive. Moreover, doing everything in-house, makes them feel masters of their own operation.

NOT SO

A professional cutting company, like MACSTEEL VRN, can cut and supply at 5-7½ per cent cheaper than you can. Probably more.

WHY

1. Since we are specialists, our scrap rate is likely to be lower than yours. Drop-outs and off-cuts which you cannot use, can be utilised by us on other jobs.

2. No rejects. Errors are our loss, not yours. You pay for what you get. No rejects in the scrap bin which you don't know about.

3. Better use of manpower. Rather put those people employed in the management and operation of the cutting machines to use in the business you specialise in, and leave the cutting to us. With the same staff, you obtain greater productivity.

4. No losses through machine-failure, absenteeism or part-utilisation of facilities.

5. You can convert factory-space presently occupied by cutting machines and steel stocks to better use by fabricating more products you can sell. Possibly you do not have to build that expensive dead capital extension to your works.

6. Cash is generated quicker. Why tie up your cash in steel stocks and machines, when you can use it to finance more finished products or to reduce debt. The quicker you can turn over your working capital, the higher the profits. When you use a steel service centre you only start paying when the cut steel is already in your yard.

7. Get what you want when you want it. No need to plan your production requirements 3-4 months ahead and then find you are short of steel. We will deliver your monthly or weekly requirement on time, every time.

8. Quality and service is our livelihood. Without it we don't exist, that's why we have to be the best. That's good for you.

A profile cutting centre should be regarded as an extension of your manufacturing operation, not as a supplier. An extension, moreover, for which you only pay when you need it. At the end of the day we will help you simplify your business. That means higher productivity.

We want to be your partner to help you save time and make money.

Questions frequently asked about High Strength and Hard Wearing Steels

Q. Can these steels be Welded?

A. Yes. The carbon content is almost the same as mild steel. Use a low hydrogen rod. It is far easier to weld than Bennox, (SS 10/200) which is a high carbon steel.

Q. Can these steels be drilled?

A. Yes, you can drill all the grades up to 400 Brinell. Keep a constant amount of pressure on the drill and do not stop-start the drill as this will harden the steel even more and you could damage the bit. For steels harder than 500 BHN, other techniques are required for providing holes.

Q. Can this steel be Flame Cut?

A. Yes. You can use normal oxy-fuel cutting methods. There are no special techniques needed such as with Stainless steel where you need Plasma Arc.

Q. What life can I expect?

A. In a normal abrasive application you can expect between 3-6 times the life of mild steel and at least double that of SS 10/200 from VRN 360. VRN 500 may last twice as long as VRN 360.

Q. What Savings are there?

A. VRN 360 costs about 2. 1 times the price of mild steel and if you get only 3 times the life you are already saving money. Then there is the savings in making only 1 liner, etc., against 3, plus the added savings of downtime and better utilisation of labour.

Q. What give these steels their hardness?

A. The roller quenching and tempering process which retains workability. The low carbon and low alloying ensure that welding, drilling and cutting are not really affected.

Q. How does the heat of Welding and Cutting effect the steel?

A. The tempering temperature of the steel is around 400°C. Even if this temperature is exceeded, the affected zone is very limited (perhaps 6 mm) because of the dissipation of heat into the rest of the plate. There will only be a drop in Brinell hardness of a few points unless extreme heat is used.

Steel type	Brinell hardness	CHEMICAL COMPOSITION											
		C max.	Mn max.	P max.	S max.	Si max.	B max.	Mo max.	Ni max.	Cr max.	Nb max.	V max.	Ti max.
VRN 200	Approx. 200	.040/ 0.55	0.70/ 1.00	0.05	0.05								
VRN 360	360 min	0.25	1.6	0.03	0.01	0,60	0.005	0.75	1.3	0.80			
VRN 400	360 min	0.20	1.8	0.03	0.03	0.70	0.005	0.8	1.2	1.00	0.06	0.10	0.04
VRN 500	450 min	0.35	1.8	0.035	0.03	0.70	0.005	0.8	0.8	1.00	0.05	0.10	0.02
VRN Ti Hard	Typical 450	0.35	1.6	0.03	0.03	0.55	0.004	0.5		1.5		0.10	0.5
VRN 600	570 min	4.00 min	4.00			1.0		1.4		32			
VRN T 690*	Approx. 260	0.2	1.6	0.02	0.01	0.5	0.005	0.70	1.5	1.5			
CREUSABRO 8000	Typical 470	0.28	1.6	0.015	0.05			0.2	0.4	1.6			
BUTTONS	Typical 750	3.0	1.5	0.1	0.1	0.1		3.5	1.0	7.0			

* Structural Grade. For comparison only

VRN BOLTS

VRN BOLTS are specially designed bolts for use with high hardness steel liners.

The bolts are through hardened up to 450 Brinell hardness in order to resist wear.

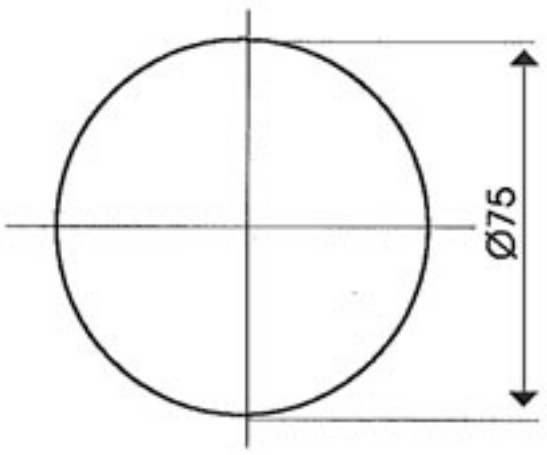
An outstanding feature of the bolts is the raised head which effectively plugs the bolt hole in the liner, thus preventing premature wear around the hole.

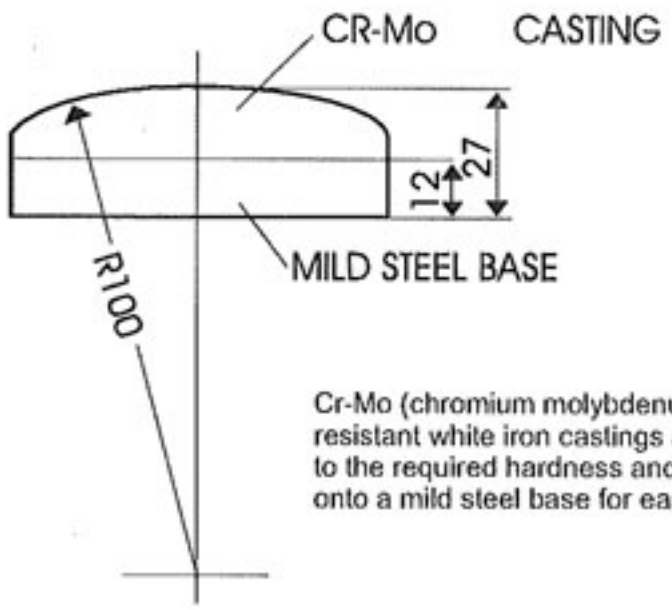
Sizes available are

M 12
M 16
M 20

CAF WASHERS
FLAT WASHERS
NUTS (ISO 4032 GR8)

VRN BUTTONS





Cr-Mo (chromium molybdenum) abrasion resistant white iron castings are heat treated to the required hardness and vacuum brazed onto a mild steel base for ease of welding.

VRN 360/400 ROLLER QUENCHED AND TEMPERED STEEL

What to consider in the selection of an abrasion-resisting steel

Many considerations are involved in the selection of the proper grade of abrasion-resisting steel. For example: the type of service, the type of material being handled, the type of abrasion, and the economics of operation.
Wear problems can best be solved by selecting a grade for trial, shaping it into an experimental part and observing the wear rate. However, the following generality can be stated: as the hardness increases, the resistance to abrasion increases. Excessive hardness, however, should be avoided so as not to cause problems in forming, or in premature failure owing to lack of impact strength.

Sliding Abrasion

In this type of abrasion, the surface is worn away by friction - due to the sliding of the load on the steel.
Generally, HARDNESS is the most significant factor in controlling the wear of steel caused by sliding abrasion, since the resistance to the abrading particles penetrating the metal depends on the HARDNESS of the metal. Higher HARDNESS provides greater wear resistance in sliding-abrasion applications, such as frames, chutes, hoppers and earthmoving equipment.

Impact Abrasion

In this type of abrasion, the surface is worn away by gouging, spalling or cutting caused by the impact from heavy, hard materials, such as rock.
The energy of a sudden blow may crack or spall a brittle material. TOUGHNESS must be combined with HARDNESS for such impact-abrasion applications as mine cars, primary chutes, wear plates, clamshell buckets, truck body liners, and so on.

Strength

Although abrasion-resisting steels are not sold to specific strength levels, the following table, offered for general information purposes, shows the approximate tensile strength for the various hardness levels:

Brinell Hardness Number	Approximate Tensile Strength MPa
321	1100
340	1170
360	1240
400	1380

Another Consideration - Fabricability

When selecting a grade for a particular application, consideration must be given to the fabricating characteristics of abrasion-resisting steels, as well as their hardness and toughness.
As outlined in the following discussion, roller quenched and tempered abrasion-resisting plates are produced from fully killed, fine-grained steels. The balanced chemistry and heat treatment produce a more uniform product with higher hardness and improved service life when compared to as-rolled abrasion-resisting steels.

Most Efficient Quench

The roller-quenching facility produces the most efficient quench possible. It exposes the entire plate surface to a rapid high-volume, high-pressure quench, producing a uniform and effectively hardened plate - ideal for abrasion-resisting applications.

Flatness

Because of the hardness of these abrasion-resisting grades, it is not possible to produce plates with flatness equivalent to that obtained on the 690 MPa minimum yield strength (quenched and tempered) grades. Some distortion may also be expected when plates are cut, because the low tempering temperatures necessary do not remove residual internal stresses.

Heat Treatment

The quenched and tempered abrasion-resisting plate steels are:

1. Austenitized at approximately 900°C.
2. Roller quenched with water to produce the most effective and uniform quench possible.
3. Tempered in the neighbourhood of 425°C to obtain the desired toughness.

Cutting

SHEARING - if high-capacity shears are available and provided care is taken, abrasion-resisting quenched and tempered plates can be sheared in thicknesses up to 25mm. Shear capacity will be only about 40 per cent of the rating for conventional structural as-rolled plates. We do regard gas cutting, plasma cutting and laser cutting as the preferred methods.
GAS-CUTTING - Procedures used on conventional structural grade steels are satisfactory. The flame-cut edges of plates are hardened by the operation to a hardness of approximately 400 + Brinell, but this is not detrimental unless cold forming is to be done.

Machining

Because of the high hardness, machining operations are more difficult than on conventional structural grade steels. However, normal machining operations can be performed by using high-speed tool steels if the cutting speeds are reduced to about 50 per cent of those used on conventional structural grade steels.

Punching

Punching and blanking operations are not recommended for the abrasion-resisting steels.

Bending and Forming

A limited amount of cold forming or bending can be done on these abrasion-resisting steels if proper precautions are taken, as follows:

1. Except for minor forming, it is essential to condition the flame-cut edges of plates before forming to remove notches and irregularities. Conditioning is most conveniently done by grinding. Also, it may be helpful to soften the edges by tempering with a torch, using temperature-indicating crayons, to avoid exceeding 425°C. For severe bending it may be necessary to completely remove the heat-affected area resulting from flame cutting.
2. A generous forming radius should be used, preferably four times the plate thickness or greater.
3. Major forming should be done transverse to the rolling direction, not parallel to it.
4. Abrasion-resisting grades have greater spring-back than conventional structural grade steels, and proper allowance must be made for this characteristic.

VRN 500 ABRASION RESISTANT STEEL PLATE

VRN 500 is a quenched and tempered high-hardness alloy steel which has superior abrasion resistance, micro-cleanliness, and toughness. This steel is an advancement on VRN 360 and VRN 400 grades.
The superiority of VRN 500 is due to desulpherisation and inclusion shape control characteristics.

1. CHEMICAL COMPOSITION (TYPICAL)

C	Mn	Si	P	S	Cr	Mo	V	Ti	B
0.35 (Max.)	1.80 (Max.)	0.70 (Max.)	0.035 (Max.)	0.03 (Max.)	0.4-1.2	0.1-0.5	0.1 (Max.)	0.02 (Max.)	0.005 (Max.)

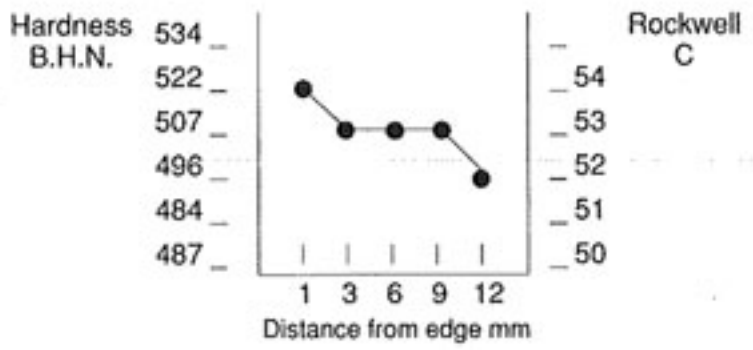
2. MECHANICAL PROPERTIES. (Typical Values)

2.1 Hardness.

The hardness range is as follows:

Brinell H.N.	450 - 550
Rockwell C	45-54
V.H.N.	480-580

Fig. 1 Hardness traverse on 25 mm VRN 500 plate.



2.2 Tensile Strength. VRN 500 is produced to meet specific minimum surface hardness requirements and not tensile requirements, however typical stress strain data is as follows:

Tensile Strength	1 880 MPa max.
Yield Strength	1 650 MPa max.
Elongation (50 mm)	14%
R.A. at point of fracture	35%

2.3 Charpy V. Notch Impact Resistance Tests. (Typical Value)

50-60 Joules at ambient temperature.

3.0 FABRICATION.

3.1 Cold Forming. Limited cold forming may be performed on VRN 500
Edge preparation by grinding is advised.
Flame cut edges should be tempered at 200°C max. prior to grinding the edges if difficult radii are to be encountered.

NB
Major forming should be done transverse to the rolling direction and not parallel to it.

3.2 Flame Cutting. Modern flame cutting practice may be employed, however it is advisable to pre-heat from 65 to 120 C immediately ahead of the torch.

3.3 Hot-working. VRN 500 is tempered at a temperature of 200 - 400 C and to ensure that full hardness is retained, the steel should therefore not be hotworked at temperatures exceeding 250 C.

3.4 Drilling. Alternative attachment methods such as hole fabrication with oxy-fuel processes or stud welding should be considered. Drilling of this plate is difficult and costly.

4. APPLICATIONS.

VRN 500 steel plate is one of the hardest known roller quenched and tempered plates. This steel will reduce material handling costs to a minimum for earthmoving, mining and other similar industries in which a combination of toughness and abrasion resistance is required. Wear plates for truck bodies, chute liners and storage-bin liners are typical applications.

When working with these steels, it is important that the fabricator is fully aware of their unique properties and understands the necessary changes that have to be made to standard manufacturing procedures. See the section on welding the abrasion resistant steels in this catalogue.

STANDARD STOCK LIST PLATES/GROFPLAAT

VRN 400

12000	x	1800	x	6	mm
12000	x	2000	x	8	mm
12000	x	2400	x	10	mm
12000	x	2400	x	12	mm
12000	x	2400	x	16	mm
12000	x	2400	x	20	mm
12000	x	2400	x	25	mm
12000	x	2400	x	30	mm
8000	x	2400	x	32	mm
11000	x	2400	x	35	mm
9600	x	2400	x	40	mm
7600	x	2400	x	50	mm
6200	x	2400	x	60	mm
5700	x	2400	x	65	mm
5200	x	2400	x	70	mm
4800	x	2400	x	75	mm
4500	x	2400	x	80	mm
3600	x	2400	x	90	mm
4000	x	2400	x	100	mm

VRN TI-HARD

12000	x	2400	x	6	mm
12000	x	2400	x	10	mm
12000	x	2400	x	12	mm
12000	x	2400	x	16	mm
12000	x	2400	x	20	mm
12000	x	2400	x	25	mm
12000	x	2400	x	32	mm
8000	x	2400	x	38	mm
8000	x	2400	x	50	mm

VRN 500

12000	x	2400	x	6	mm
12000	x	2400	x	8	mm
12000	x	2400	x	10	mm
12000	x	2400	x	12	mm
12000	x	2400	x	16	mm
12000	x	2400	x	20	mm
12000	x	2400	x	25	mm
12000	x	2400	x	32	mm
12000	x	2400	x	38	mm
8000	x	2400	x	50	mm

CREUSABRO 8000

8000	x	2500	x	6	mm
8000	x	2500	x	10	mm
8000	x	2500	x	12	mm
8000	x	2500	x	16	mm
8000	x	2500	x	20	mm
8000	x	2500	x	25	mm
8000	x	2500	x	32	mm
8000	x	2500	x	38	mm
8000	x	2500	x	50	mm

NB. IN ADDITION TO THE STANDARD SIZE PLATES WE DO HAVE A VARIETY OF PLATE SIZES IN THE ABOVE THICKNESSES

VRN Ti-HARD ABRASION RESISTANT PLATE

The superior wear resistance is as a result of the additional uniform dispersion of high hardness Titanium Carbide particles throughout the steel. This results in a steel of 450BHN which has an abrasion resistance over 1,5 times greater than conventional 500BHN grades, with the added advantages of improved workability of 450BHN plate.

1. CHEMICAL COMPOSITION % (TYPICAL)

C	Si	Mn	P	S	Cr	Mo	Ti	B
0.29	0.35	0.7	0.007	0.002	0.94	0.26	0.42	0.001

2. MECHANICAL PROPERTIES. (Typical Values)

2.1 VRN Ti-Hard is not produced to meet specific mechanical requirements. However, typical values will be as follows for 25,0mm thick plate:

Tensile Strength	1 470 MPa
0,2% Proof Stress	1 280 MPa
% Elongation (50mm)	16,5%

2.2 HARDNESS

Typical hardness values will be as follows:

BHN	461
HRC	48,5
VHN	491

2.3 Charpy V Notch Impact Tests

20-30 Joules at 0°C

3. FABRICATION

3.1 Cold Forming. Although Ti-Hard has excellent through thickness hardness, the steel still has a high degree of toughness, the following bending radii are suggested:

Transverse	Longitudinal
Greater than 8T	Greater than 10T

3.2 Hot Working. The steel obtains its properties through controlled heat treatment and should therefore not be hot worked at temperatures exceeding 300°C.

3.3 Flame Cutting. Ti-Hard may be readily cut using any of the conventional cutting methods such as oxy-fuel, plasma or laser.

3.4 Weldability. Ti-Hard is readily weldable using any of the usual arc welding processes. Low hydrogen procedures and low tensile strength consumables should be used. Welding consumables and procedures are the same as for all other VRN grades of wear resistant steels. Refer to "Welding the abrasion resistant grades" in this VRN brochure.

4. GENERAL

VRN Ti-Hard derives its exceptional wear resistance due to the addition of titanium to the molten steel. On solidification titanium carbide particles are formed and disperse uniformly throughout the plate.

Vickers Hardness scale illustrating the relationship between titanium carbide and other carbides.

CARBIDE TYPE & HARDNESS	
Material	HV
Diamond	9000
Titanium	3200
Vanadium	2400
Tungsten	2000
Chromium	1500
Iron	1340

CREUSABRO 8000

A wear and impact resistant steel intended for service in particularly severe mining and earthmoving applications. This steel exhibits outstanding wear characteristics when compared to conventional liner materials.

CHEMICAL COMPOSITION (%)

C	Mn	Ni	Cr	Mo	S	P
0.280 (max)	1.60 (max)	0.40 (approx)	1.60 (max)	0.20 (min)	0.005 (max)	0.015 (max)

DESCRIPTION

Wear resistance:

The CREUSABRO concept - excellent work hardening ability combined with the deliberate addition of wear resistant microcarbides. The steel work hardens due to the TRIP effect. (Transformation induced through Plasticity). This combination of properties gives CREUSABRO 8000 exceptional wear and impact resistance combined with outstanding properties throughout the thickness.

Controlled as delivered hardness range:

Minimum 450BHN, typically 470BHN

High toughness and impact resistance:

CVN (L) at -20°C:>40 J/cm² (23,6 ft-Lbs)
Typical value at -20°C: 55J/cm² (32 ft-Lbs)

Tensile strength - typical values at 20°C-:

Ultimate tensile strenth = 1 630 MPa (235 ksi))
Yield strength = 1 250 MPa (180 ksi)
Elongation (5d) = 12%

APPLICATIONS

CREUSABRO 8000 is intended for applications requiring extreme resistance to wear and impact in all mining, earthmoving and materials handling environments.

Cold forming

Bending: inside radius > 6T
width of V-block > 40T
Rolling: inside diameter > 40T
(where T = plate thickness)

Welding

CREUSABRO 8000 may be welded using any of the standard welding processes. The use of low hydrogen consumables is important. Refer to the section on "Welding the abrasion resistant grades" in this catalogue.

Welding the abrasion-resistant grades (VRN 360/400/500, Ti-Hard, Creusabro 8000)

All of the wear and abrasion-resistant grades supplied by MACSTEEL VRN are readily weldable by any of the common welding processes, using appropriate procedures. Consumables with a lower yield and tensile strength than the base metal are recommended. Low hydrogen S.M.A.W electrodes ar the gas metal arc (MIG) process are suggested.

S.M.A.W. electrodes conforming to A.W.S. A5, 1, E 7015, E 7016, E 7018 or G.M.A.W. wire conforming to AWS A5, 18, ER 70S - 6 should be used.

WELDING RECOMMENDATIONS

The two main objectives when welding abrasion resisting steels should be:

- to prevent cracking
- to minimize the softening in the heat-affected zone caused
  by the tempering action of the welding heat.

1. Hydrogen level

This can be kept low by using a low-hydrogen process, such as gas-metal-arc, or ensuring that the coating of manual metal-arc electrodes or the flux used for submerged-arc welding is thoroughly dry. (refer to maker's instructions). Further, the plate must be dry and free from oil and grease before welding is commenced.

Always ensure that the filler metal has a low hydrogen content (HD≤5ml/100g).

2. Microstructure

This concerns the formation of hard martensite in the heat-affected zone (HAZ) owing to a too rapid rate of cooling caused by a low welding heat input.
This is counteracted by specifying minimum preheat levels and also minimum heat input levels, as shown in the table. These values ensure a sufficiently slow rate of cooling of the weld to produce a satisfactory microstructure.

3. SOFTENING OF HEAT-AFFECTED ZONE

Since the hardness is imparted to the plate by a quenching process, this hardness will be destroyed by subsequent heating. It is, of course, impossible to avoid a certain
amount of retempering, i.e. softening, but this can be minimized by limiting the heat input to a predetermined maximum value. For the purpose of this note, a drop in hardness to about 270 Brinell Hardness (28 Rockwell C) has been allowed, Whereby the maximum heat input values can be exceeded if a softer HAZ can be tolerated, e.g. in hidden corners.
If it is considered essential to provide abrasion resistance in the weld bead itself, it is desirable first to deposit soft steel beads and apply wear-resistant beads at the surfaces only.

4. Preheat

Preheat is necessary in order to prevent the formation of a hard, brittle microstructure in the heat-affected zone and to allow any diffusable hydrogen to escape from the weld and H.A.Z.

The recommendations as laid out in EN1011 should be applied while taking into consideration the higher hardness and strength of these steels.

5. Stress reliving

Stress relieving should not be carried out on the wear-and-abrasion-resistant grades. Stress-relieving temperatures are generally above the tempering temperature of the steel and will result in softening. When welding the abrasion-resistant grades to other grades of steel, contact the Technical Department at MACSTEEL VRN for information

Combined thickness (up to and including)	Minimum preheat temperature (C)	Minimum heat input (kJ/mm)	Maximum* heat input (kJ/mm)
6 mm	20	0.6	1.4
12 mm	50	1.1	1.9
25 mm	100	2.1	2.3
32 mm	125	2.3	2.8
100 mm	175	2.3	3.2

* Can be exceeded if a wider softer heat-affected zone can be tolerated

VRN 600 OVERLAY PLATE

VRN600 is an iron-chromium-carbide alloy which has been fused onto a mild steel backing plate. The ultra-hard chromium carbide particles are suspended in a hard, tough matrix, a combination which offers optimum abrasion resistance. The mild steel backing material allows VRN 600 to be rolled, bent, formed and fabricated into a multitude of abrasion-resistant applications.

Appearance

During the overlay process, the stresses present due to expansion and contraction are relieved by cracking of the hard surface deposit. Crack frequencies of more than one crack per 25 mm are desirable and indicate that there is no simultaneous cracking away of the hard layer from the mild steel base.

Wear Life

Data obtained from in-service tests indicate that VRN 600 overlay plate will substantially outlast conventional liner materials in high abrasion, medium impact and high temperature applications.

TECHNICAL SPECIFICATIONS.

Minimum hardness	550B.H.N.
Average S.G.	7,9
Backing plate	Structural steel
Standard bead width of overlay	28 mm
Overlay thickness	3,2 mm - 10 mm
Backing plate thickness	5 mm - 20 mm
Maximum operating temperature	680°C (sustained)
Plate size (Max)	2 900 mm x 2 200 mm

Fabricating

VRN 600 may be cut, formed and rolled to a variety of shapes and configurations.

Cutting

Plasma arc cutting is recommended.

Welding

Backing plate can be welded with standard carbon steel electrodes.

Rolling

Minimum Rolling Radius (internal) 20 x material thickness
Minimum Rolling Radius (external) 50 x material thickness

TYPICAL APPLICATIONS.

Power

Fan Blades and liners, Classifier cones, Ash removal conveyors. Chutes.

Paper & Pulp

Fan blades and liners, Cyclone liners, Bark chutes, chipper Hood liners, Belt Conveyor transfer bins, Screw Conveyors, Tube turns, Transmission Sections.

Dredging

Pump Shells, Impellers, Trunnion elbows, Distribution Troughs, Rock Boxes, Drag Heads, Side liners, Ball joints, Reducers, Flap Valves.

Cement

Clinker Chutes, Hopper liners, Fan Blades and liners, Dust sections, Vibration Screen Decks, Air separator wear plates, Impact crusher liners, Grinding Ring Segments.

Refinery

Inlet cones, Flapper plates, Lift Belts, Patch Plates.

Mining

Truck Bed Wear Protective Systems, Shovel and Bucket Wear Protection Systems. Vibrating Screen Decks, Chute liners, Fan blades, Hopper liners, trunnion liners, Wear caps, Vibrating pans, Main Frame Crusher Liners.

Steel

Chute and Hopper liners, Fan blades and liners, Main Ram support shoes, Septum valves, Small bell and bell seats, Bucket liners, Reclaimer Buckets, Skip car plates, Scroll and cheek plates, Table wear plates, Screen Deck plates, Flapper Gates, Grizzly Bars, Plough Blades, Bell-less Furnace Distribution Chutes.

Methods of attachment

VRN 600 clad base material can be welded with a standard carbon steel electrode; heat treatment is not required. Common methods of welded attachment are peripheral edge welds and plug welds. Alternate methods of attachment include countersunk studs and countersunk bolts.

VRN 200

VRN 200 is a high-carbon steel which is suitable for hard wearing applications which are not sufficiently severe to warrant more sophisticated steels. This material is used for liner plates and scraper blades, preferably fitted by drilling and bolting.

NOMINAL ANALYSIS
0,4% - 0,55% C, 0,7% - 1,0% Mn, 0,15% - 0,35% Si

TYPICAL HARDNESS
Approx. 200 BHN. (Not measured or guaranteed).

FLAME CUTTING
May be cut with pre-heating recommended for thicker sections.

WELDABILITY
VRN 200 is a difficult steel to weld due to its high carbon equivalent.
Welding should be used for joining purposes only and is not recommended under high stress conditions.
Hydrogen controlled electrodes should be used with a minimum preheat of 250°C. For austenitic electrodes, use a minimum preheat of 150°C. Cooling rates after welding should be controlled.

SHEARING
VRN 200 can be sheared in thicknesses up to 25 mm, provided sufficient power is available. Cutting edges must be sharp and clearances set correctly.

PUNCHING
VRN 200 up to 12 mm can be punched provided tools are sharp and clearances are set correctly.

STANDARD STOCK LIST PLATES/GROFPLAAT

AVAILABLE IN THICKNESSES FROM
6mm TO 50mm IN SIZES

2400 x 1200
4000 x 2400
6000 x 2400
8000 x 2400
12000 x 2400 (6 - 25mm)

STRUCTURAL STEELS

Chemical Composition

The following weldable structural steels conforming to national and international specifications, are available from VRN steel. All these grades are readily weldable by means of the usual arc welding processes. When welding thicker sections, reference should be made to BS 5135: 1974 "Metal-arc welding of carbon and carbon manganese steels", to establish possible pre-heat requirements. Carbon equivalent (C.E.) values should be calculated from the chemical composition values as recorded on the test certificates.

CHEMICAL COMPOSITION (MAX)

MATERIAL	C	Mn	Si	S	P	Cr	Mo	Cu	Ni	Nb	V	B
BS 4360 GRADE 43A	0.25	1.6	0.5	0.05	0.05	-	-	-	-	-	-	-
SANS 1431 GRADE 300WA	0.22	1.6	0.5	0.05	0.04	-	-	-	-	MAX 0.1 IF COMBINED		-
BS 4360 GR 50C / EN 10025 S355JO	0.22	1.6	0.5	0.05	0.05	-	-	-	-	0.003/ 0.1	0.003 0.1	-
SUPRAFORM TM 380	0.10	1.2	0.03 (typ)	0.020	0.020	-	-	-	-	0.015		-
VRN T690	0.2	1.6	0.5	0.01	0.02	1.5	0.70	-	1.5	-	-	<0,005

TYPICAL MECHANICAL PROPERTIES

MATERIAL	Nominal Thickness (mm)	Tensile Strength (MPa)	Min. Yield Strength (MPa)	% Elong in 200 mm (Min)	Impact Strength J (Min)
BS 4360 GRADE 43A	5 - 150	430 - 580	225 - 275 (Depends on Thickness)	20	Not specified or measured
SANS 1431 GRADE 300WA	5 - 150	450 - 620	270 - 300 (Depends on Thickness)	20	Not specified or measured
BS 4360 GR 50C / EN 10025 S355JO	5 - 250	490 - 680	275 - 355 (Depends on Thickness)	18	27 @ 0°C
SUPRAFORM TM 380	4 - 10	450 min	380 - 460	22	Not specified
VRN T690	6 - 150	760 -895	690	18 (in 50 mm)	60 @ - 50°C (L) 50 @ - 50°C (T)

STANDARD STOCK LIST PLATES/GROFPLAAT

PLATES - GROFPLAAT BS 4360 - 43A
SANS 1431 - 300WA

Nominal Size Millimetres	Nominal Size Millimetres	Nominal Size Millimetres	Nominal Size Millimetres
2500 x 1200 x 5	2500 x 1200 x 16	2500 x 1200 x 40	2400 x 1200 x 90
4000 x 2400 x 5	4000 x 2400 x 16	4000 x 2400 x 40	4000 x 2400 x 90
6000 x 2400 x 5	6000 x 2400 x 16	6000 x 2400 x 40	4000 x 2400 x 100
10000 x 2400 x 5	10000 x 2400 x 16	10000 x 2400 x 40	4000 x 2400 x 100
2500 x 1200 x 6	2500 x 1200 x 20	2500 x 1200 x 45	4000 x 2400 x 120
4000 x 2400 x 6	4000 x 2400 x 20	4000 x 2400 x 45	4000 x 2400 x 125
6000 x 2400 x 6	6000 x 2400 x 20	6000 x 2400 x 45	4000 x 2000 x 135
10000 x 2400 x 6	10000 x 2400 x 20	10000 x 2400 x 45	4000 x 2000 x 150
2500 x 1200 x 8	2500 x 1200 x 25	2400 x 1200 x 50	4000 x 2000 x 180
4000 x 2400 x 8	4000 x 2400 x 25	4000 x 2400 x 50	4000 x 2000 x 200
6000 x 2400 x 8	6000 x 2400 x 25	6000 x 2400 x 50	4000 x 1000 x 250
10000 x 2400 x 8	10000 x 2400 x 25	2400 x 1200 x 55	3000 x 2000 x 250
2500 x 1200 x 10	2500 x 1200 x 30	4000 x 2400 x 55	2500 x 1500 x 300
4000 x 2400 x 10	4000 x 2400 x 30	6000 x 2400 x 55	
6000 x 2400 x 10	6000 x 2400 x 30	2400 x 1200 x 60	
10000 x 2400 x 10	10000 x 2400 x 30	4000 x 2400 x 60	
2500 x 1200 x 12	2500 x 1200 x 32	6000 x 2400 x 60	
4000 x 2400 x 12	4000 x 2400 x 32	2400 x 1200 x 65	
6000 x 2400 x 12	6000 x 2400 x 32	4000 x 2400 x 65	
10000 x 2400 x 12	10000 x 2400 x 32	6000 x 2400 x 65	
	2500 x 1200 x 35	2400 x 1200 x 70	
	4000 x 2400 x 35	4000 x 2400 x 70	
	6000 x 2400 x 35	6000 x 2400 x 70	
	10000 x 2400 x 35	2400 x 1200 x 75	
		4000 x 2400 x 75	
		2400 x 1200 x 80	
		4000 x 2400 x 80	
		2400 x 1200 x 85	
		6000 x 2400 x 85	

BS4360 Grades 50C
EN 10025 S355JO

These steels fill the gap between the lower strength (300WA/43A)
structural steels and the ultra-high yield structural steels. eg VRN T690. These steels are supplied in the normalised condition (50B < 12,5mm as-rolled) and are silicon killed in order to improve the steel cleanliness, and to ensure fine grain structures. Test certificates are supplied with each consignment.

Welding
As with lower grades of mild steel, procedure is dependent on the Carbon content as reflected on each Test Certificate. For more comprehensive information in this respect B.S. 5135 should be referred to.

Cold Forming
These steels can be formed at room temperature provided adequate power is available and the correct process is employed. A working 20% uprating on mild steel requirements is recommended making use of the following inside radius forming tolerances.
2½t for right angle forming (to rolling direction)
3t for forming in parallel (to rolling direction)

A trial run may be necessary in order to determine the springback allowance for close tolerance work.

Punching, Drilling, Shearing and Machining
Equipment should be regulated to allow for the 20% increase in strength as opposed to that of conventional mild steels. High-speed steel or Carbide tooling is recommended, speeds should be reduced by approximately 20% and a good lubricant/coolant will increase tool life. When punching or shearing, a clearance of approximately 3% should be allowed for the shear angle.

Cutting
Conventional Flame cutting equipment can be used without resorting to pre- or post-heating operations.

Applications
Mine fans, earth moving buckets, trailers and large road vehicles, drill rigs, cranes, excavators, underground mining equipment, bridges and other high strength components requiring superior toughness.

Dual Certification
Although the steel is duel certified to
BS 4360 GR 50C / EN 10025 S355JO, it also meets the requirements of SANS 1431 GR 350WC

Thickness Range

12000	x	2400	x	5 mm
12000	x	2400	x	6 mm
12000	x	2400	x	8 mm
12000	x	2400	x	10 mm
12000	x	2400	x	12 mm
12000	x	2400	x	16 mm
12000	x	2400	x	20 mm
12000	x	2400	x	25 mm
8000	x	2400	x	30 mm
8000	x	2400	x	32 mm
8000	x	2400	x	40 mm
7000	x	2400	x	45 mm
7000	x	2400	x	50 mm
4000	x	2400	x	60 mm
4000	x	2400	x	65 mm
4000	x	2400	x	70 mm
4000	x	2400	x	75 mm
4000	x	2400	x	80 mm
6000	x	2000	x	90 mm
6000	x	2000	x	100 mm
4000	x	2400	x	125 mm
4200	x	2000	x	150 mm

SUPRA FORM TM 380

High-strength low-alloy (H.S.L.A.) steels have been commercially available for some time now. However, they have suffered from the disadvantage that they are generally available in thicker sections, need special precautions when being welded and, because of their high strength, are more difficult to form.
MACSTEEL VRN now stock SUPRAFORM TM 380, a steel which overcomes the above limitations.
TM 380 is a H.S.L.A. steel, has a minimum yield strength of 380 MPa and, because of the low carbon content, typically 0,06%; has excellent weldability when using any of the standard arc or resistance processes, without the need to take any special precautions. Severe forming can readily be carried out on TM 380 due to its superior formability, thus further increasing the steel's versatility.
With the need for higher yet stronger structures, effective mass savings can be achieved without the penalty of reduced overall strength by selecting a steel which has a combination of higher tensile and yield strengths and reduced thickness.
Typical applications for TM 380 are body and chassis components for tipper trucks, bumper brackets, engine mounting brackets, crane jibs and booms, trailers, mining equipment, rolling stock, cold formed sections, etc.

Typical chemical composition % (ladle analysis)

SUPRAFORM grade	C	Mn	Si	P	S	Al	Nb
TM 340	0.05	0.35	0.03	0.015	0.006	0.03	0.013
TM 380	0.06	0.55	0.03	0.015	0.006	0.03	0.015
TM 420	0.07	0.85	0.08	0.015	0.006	0.03	0.028
TM 460	0.08	1.15	0.08	0.015	0.006	0.03	0.033
TM 500[1]	-	-	-	-	-	-	-

1) Availability on application only

Mechanical properties

SUPRAFORM GRADE	Tensile strength	Yield strength	Elongation (% min) gauge length 50 mm		180° Bend test (mandrel dia)
	MPa (min)	MPa	t < 3,0	t > 3,0	
TM 340	400	340/420	22	24	0,5t
TM 380	450	380/460	20	22	0,5t
TM 420	490	420/500	19	21	0,5t
TM 460	530	460/560	18	20	1,0t
TM 500[1]	560	500/600	-	-	-

NOTE: Tensile test to BS 18 part 2 or 3. Bend test BS 1639
1) Availability on application only

STANDARD STOCK LIST

SUPRAFORM - TM 380

4500	x	1250	x	4 mm	TM 380
4600	x	1250	x	5 mm	TM 380
4600	x	1800	x	6 mm	TM 380
4600	x	1365	x	8 mm	TM 380

VRN T690
FABRICATION

Cold forming
VRN T690 steel plates can be readily formed or bent at ambient temperature if adequate power is available and proper procedures are used. Generally, the power required to form VRN T690 will be three times that required for low strength structural steel. The springback after forming is also considerably greater than on low strength structural steel and due allowance must be made. A trial run may be necessary to determine the springback allowance for close tolerance work. The suggested minimum inside radius for forming VRN T690 steel plate is given below:

Plate thickness (T) in mm	Minimum inside Radius
Up to 25mm, inclusive	3T (Transverse)
Above 25 to 50 mm, inclusive	4T (Transverse)

The following precautions should be taken for bending operations:
1. Use the largest radius permissible.
2. Major bends should be made on a line which is perpendicular to the length of the plate (rolling direc tion), if possible.
3. The outside radius should not be restrained. Closed-die forming may require doubling the suggested radii to avoid breakage.
4. For press brake forming, the lower die span should be at least 16 times the plate thickness. If design requirements will not permit this, the bend should be started with an upper die of larger radius.
5. The minimum tensile requirements (780 to 930 MPa) should be waived whenever severe forming is antici pated. This will enable us to produce the lowest possible yield strength consistent with the specification.
6. Sharp notches on the edges of plates resulting from shear breaks or torch cutting may require removal by grinding or machining to prevent cracking during severe forming.
7. Roll forming of cylindrical sections should be preceded by crimping of the butt edges.
8. Extremely severe forming should be done after heating the plate to 540/595°C.
9. Deep scratches or gouges on the outside radius may cause cracking on severe bends. This condition may be corrected by grinding out or buffing the scratches.

Shearing
VRN T690 steel plate can be cold sheared up to and including 25 mm thickness if the capacities of the shear and the shear knives are adequate. A shear capable of cutting 38 mm low strength structural steel is required to shear 25 mm plate of VRN T690 steel. The capacity of smaller shears should be down rated in proportion, i.e., the capacity is decreased about 33 per cent when VRN T690 is sheared.

The clearance on the shear knives should be less than the conventional 5 per cent of plate thickness, usually about 2 per cent. A compromise clearance to accommodate all plates from 6 mm to 25 mm in thickness would be about 0,4 mm. Knives should be kept sharp to avoid ragged edges.

Punching
Holes may be punched in VRN T690 plates up to and including 12 mm in thickness as long as the hole diameter is greater than the plate thickness. Punch and die clearance should be close, as described for shearing, and the tools should be kept sharp. Greater thicknesses can be punched; however excessive punch wear may result.

Machining
VRN T690 steel plates can be machined with conventional equipment using either high-speed steel or carbide tooling. Because of the relatively high hardness of VRN T690 steel as compared to carbon structural steel, the cutting speeds should be about 30 per cent less in order to obtain reasonable tool life. A coolant should always be used if available as an aid to tool life. When extensive machining is necessary on torch cut edges, it may be found essential to soften the edges. This can be done by tempering the entire plate, or only the edges, in a temperature range of approximately 540° to 595°C. If a furnace is not available, the edges can be softened with a torch as long as precautions are taken to avoid exceeding a temperature of 595°C.

Torch cutting
VRN T690 steel plate can be cut with conventional oxygen-fuel gas equipment without the necessity of preheating or postheating, employing the same practices used for soft carbon steels. Stack cutting of plates, however, should be avoided because of excessive heat inputs required.
As with any structural steel, the smoothness of the cut is affected by scale on the surface of the plates.
Plasma-jet torch cutting is suggested wherever available and is advantageous because of the high cutting speed, the smoothness of the cut, and the shallow heat-affected zone produced.
On multiple cuts, balanced torch settings will help avoid distortion.

Applications
VRN T690 is very high strength structural steel and can result in greater load carrying capacities and lighter structures when used in place of conventional structural steels.
Uses include:
- Earthmoving equipment
- Dump trucks
- Trailers
- Mobile cranes
- Drilling rigs
- High speed fans
- Bridges

STANDARD STOCK LIST PLATES/GROFPLAAT

VRN T690 is a roller quenched and tempered alloy steel designed to provide an excellent combination of high strength (690 MPa minimum yield strength), toughness, abrasion resistance, and weldability. This improvement in physical properties of VRN T690 is obtained through increased alloy content which results in increased hardenability.

MECHANICAL PROPERTIES	
Minimum yield strength at 0,2% offset (MPa)	690
Tensile strength (MPa)	780-930
Minimum elongation in 50 mm (%)	18*
Minimum reduction of area (%)	40**, 50**
Brinell hardness, typical	235/293
Toughness properties may be specified:	

* A deduction of 1,25 per cent may be made for each decrease of 0,8 mm of specified plate thickness under 8 mm, up to a maximum deduction of 3 per cent
** If full-section flat specimens are used, 40 per cent applies. If a standard, machined round specimen is used, 50 per cent applies

VRN T690

6000	x	1300	x	3 mm
6000	x	1300	x	4 mm
12000	x	1800	x	6 mm
12000	x	2400	x	8 mm
12000	x	2400	x	10 mm
12000	x	2400	x	12 mm
12000	x	2400	x	16 mm
12000	x	2400	x	20 mm
12000	x	2400	x	25 mm
12000	x	2400	x	30 mm
8000	x	2400	x	32 mm
9600	x	2400	x	40 mm
7600	x	2400	x	50 mm
6200	x	2400	x	60 mm
5700	x	2400	x	65 mm
4800	x	2400	x	75 mm
4500	x	2400	x	80 mm
6000	x	2400	x	90 mm
6000	x	2400	x	100 mm
4000	x	2100	x	125 mm
4000	x	2400	x	150 mm

VRN T690 WELDING

General

The VRN T690 low alloy grades of steel were developed to be easily weldable. High strength in structural steels may be achieved either by addition of alloying elements or by thermal treatment, as with the VRN T690 steels. They are quenched and tempered and contain a minimum of alloying elements which render them easily weldable.

Most of the well known fusion welding processes may be employed on VRN T690 steel. Fusion welding involves depositing molten weld metal in order to achieve a joint. The chemical analysis and the cooling rate of the weld metal can be controlled. However, the region directly adjacent to the weld on either side, known as the heat-affected zone (HAZ), experiences a thermal cycle, ranging from unaffected parent plate to near melting at the fusion boundary. Since the chemical analysis of the parent material is unalterable, it is important to take care of the thermal cycle of the HAZ. When welding VRN T690 plate a number of general factors have to be borne in mind. The main source of concern in welding these steels is hydrogen induced cold cracking. By minimising the sources of hydrogen and by avoiding the formation of a crack-sensitive microstructure and also by keeping stresses below certain limits, hydrogen induced cracking can be avoided. In addition, for full strength buttwelds a suitable welding consumable must be selected.

Sources of hydrogen

Dirt, grease, paint, moisture, rust, etc., on the plates to be welded should be positively removed.
The welding consumables should be of approved quality and should be clean and dry, during both storage and usage. Different welding processes have different inherent hydrogen potentials. When welding with the processes of highest hydrogen potential, greater care is required than welding with processes of lower hydrogen potential.

Avoidance of crack sensitive microstructure.
The microstructure in the HAZ is determined by the steel composition as well as the local cooling rate.
A knowledge of the steel composition is therefore essential for proper selection of welding parameters. The use of the Carbon Equivalent formula gives an indication of the degree of care required.
The CE of VRN T690 ranges between 0,37 and 0,54. In order to avoid a crack-sensitive microstructure, a suitable cooling rate in the HAZ must be maintained after welding. Generally this involves using pre-heating and controlled values of heat input during welding. The particular values of pre-heat and heat input depend upon a number of factors but average values are quoted below in Table 1. Heat input can be calculated from the formula.

$$HI = \frac{\text{Welding volts (V) x welding current (Amps)}}{\text{1000 x welding speed mm/sec}} = \frac{kJ}{mm}$$

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

It should be emphasized that the values of pre-heat and heat input quoted in Table 1 are average values. Factors such as restraint, welding position, edge preparation, service conditions (type of load), etc., may influence the particular values selected.

Welding stresses

In general it may be stated that joints of high restraint need more care when welding than joints of low restraint .
This is of particular importance when using a high-strength filler material in order to achieve a full strength joint.
The molten weld metal contracts upon cooling if free to do so, causing distortion, or creating welding residual stresses of yield point magnitude if free contraction is hampered. Values of high residual stress are conducive to distortion during subsequent machining operations and cracking in the weld or HAZ during and after welding. Welded structures should be designed for welding in order to minimise the volume of weld metal which should be deposited in the shortest possible time to effect the greatest economy.
Summarising, it may be stated that VRN T690 is a weldable quenched and tempered steel which may be successfully welded with the common fusion welding processes provided certain precautions are taken. The level of hydrogen in the deposited weld metal should be kept to a minimum, the cooling rate must be slow enough to avoid the formation of crack-sensitive microstructures in the HAZ but not so slow that excessive grain growth occurs. Pre-heating and controlled values of heat-input are therefore required.

Welding consumables

The American Welding Society Classification AWS EXXXX is a very practical and useful system. British and South African equivalents may be found in BS EN 499 and SABS 455 respectively. For practical reasons, only the AWS classification groups are quoted here.
Matching strength consumables are suggested for welding VRN T690 although lower strength consumables can be used. Consumables should conform to one of the following specifications: S.M.A.W.: A.W.S. A5.5, E 9018 or E 11018; G.M.A.W.: A.W.S. A5.28, ER 90S or ER 100S

SUITABLE CONSUMABLES FOR WELDING VRN T690

SUPPLIER	SMAW (MMA)	GMAW (MIG CO_2)
AFROX	Superweld 118	Transarc 6048
ESAB	OK 75.75	
EUTECTIC	EUS 110	
FEDGAS	Griduct 17	Fluxofill 42
OERLIKON	Armcor LH	Acros Arc 110t
ROCKWELD	Ductilent 110	McKay 117

Heat input schedule for all grades

PLATE THICKNESS	COMBINED THICKNESS*	MINIMUM PRE-HEAT °C	MINIMUM HEAT INPUT VALUES kJ/mm
10	20 30 40	35 35 35	1,0 - 1,5 1,0 - 1,5 1,0 - 1,5
20	40 60 80	50 50 80	1,0 - 2,0 1,5 - 2,5 1,5 - 3,0
30	60 90 120	50 80 100	2,0 - 3,0 2,5 - 3,5 2,5 - 4,0
50	100 150 200	80 100 125	2,5 - 4,0 2,5 - 4,0 2,5 - 4,0

Table 1. Values of pre-heat and heat input for various plate thicknesses.

* the combined thickness of a joint is the total thickness (mm) of the plates meeting at the joint line.

Heat input schedule

Stress relieving

It is generally felt that stress relieving of welded joints is not necessary. Stress relieving for prolonged periods of time at relatively high temperatures, can cause metallurgical changes which are detrimental to the mechanical properties of the steel. The table shows that 12 mm VRN T690 does not seem to be susceptible to these metallurgical changes. However, it is suggested that stress relieving at about 600°C be limited to a maximum period of 2,4 minutes per millimetre of thickness. Longer periods of exposure would be permissible at lower temperatures.

Effect of prolonged exposure during stress-relief on mechanical properties: 12 mm plate VRN T690

Stress-relief (SR)	0,2% proof stress (MPa)	Tensile strength (MPa)	Elongation in 50 mm %	Reduction in area %
Quenched and tempered	783	821	22,3	67,6
SR 1 hour at 538 °C	762	808	22,3	67,7
SR 8 hours at 538 °C	767	821	23,0	67,2
SR 24 hours at 538 °C	770	821	22,9	65,9
SR 100 hours at 538 °C	790	836	22,4	66,5
SR 1 hour at 593 °C	765	814	22,5	66,9
SR 8 hours at 593 °C	760	808	23,0	66,2
SR 24 hours at 593 °C	770	814	22,0	65,9
SR 100 hours at 593 °C	711	759	22,2	65,9

When welding VRN T690 to other grades of steel, contact the Technical Department at VRN for information.

PRESSURE VESSEL STEELS

TYPICAL CHEMICAL COMPOSITION (MAX)

MATERIAL	C	Mn	Si	S	P	Cr	Mo	Cu	Ni	Nb	V	B
BS 1501-161 GRADE 430A	0.25	0.6/1.4	0.1/0.35	0.03	0.03	0.25	0.01	0.3	0.3	-	-	-
ASTM A516 GRADE 65/70	0.31	0.85/1.2	0.15/0.4	0.04	0.035	-	-	-	-	-	-	-

MATERIAL	Nominal Thickness (mm)	Tensile Strength (MPa)	Yield Strength (MPa)	% Elong in 200 mm (Min)
BS 1501-161 GRADE 430A	5 - 75	430 - 550	220 - 250	21
ASTM A516 GRADE 65/70	6 - 50	480 - 620	260 (MIN)	17

Steels as specified in B.S. 1501 may be used for pressure vessels designed and built to the British code B.S. 5500.

1. **B.S. 1501 - 161 Grade 430A** is a carbon steel, available in thicknesses up to 150 mm. Plates up to and including 40 mm are supplied as rolled, unless requested by the customer to be normalised. Plates over 40 mm thick are supplied normalised. This steel is generally used for lower temperature service. Type 161 is manufactured employing a vacuum degassing process. This reduces the sulphur content to below 0,01% and improves the cleanliness of the steel.

Appendix D in B.S. 1501 shows the yield strength or proof stress values of the respective grades at elevated temperatures. These values may be used for design purposes, but if confirmation of the strength at a particular temperature is required, a hot tensile test at the designated temperature must be stipulated.

2. **ASTM A516 Grade 65/70**
ASTM 516 is the standard specification for Pressure Vessel Plates, Carbon Steel for Moderate and Lower-temperature Service', where improved notch tough ness is important and calls for a silicon killed steel made to a fine grain practice by adding aluminium. Plates up to and including 38 mm thick may be supplied as-rolled but may be ordered normalised. Plates thicker then 38 mm as well as plates on which notch toughness tests are required, must be normalised. Grade 516 is a fine grain steel.

ULTRASONIC TESTING

All the above pressure vessel plates in thicknesses 20 mm and greater are ultrasonically tested to B.S. 5996: 1993 Grade B 1 as a standard quality control procedure.

STANDARD STOCK LIST PLATES/GROFPLAAT

BOILER PLATE/KETEL PLAAT
BS 1501 - 161 GRADE 430A

10000	x	2400	x	5 mm
10000	x	2400		6 mm
10000	x	2400	x	8 mm
10000	x	2400	x	10 mm
10000	x	2400	x	12 mm
10000	x	2400	x	16 mm
10000	x	2400	x	20 mm
10000	x	2400	x	25 mm
10000	x	2400	x	30 mm
10000	x	2400	x	32 mm
9000	x	2400	x	40 mm
8000	x	2400	x	45 mm
6000	x	2400	x	50 mm
6000	x	2400	x	60 mm
6000	x	2400	x	65 mm
6000	x	2400	x	70 mm
4000	x	2400	x	75mm

PLATES/GROFPLAAT
ASTM A 516 GRADE 65/70N

13000	x	2500	x	6 mm
13000	x	2500	x	8 mm
13000	x	2500	x	10 mm
13000	x	2500	x	12 mm
13000	x	2500	x	16 mm
13000	x	2500	x	20 mm
13000	x	2500	x	25 mm

Application Suggestions
FOR HEAVY DUTY ABRASION-RESISTING/SHOCK LOADING COMBINATION

Baffle Plates

Bang Boards

Brick Reliners

Brick and Tile Dies

Brick Dies and Reliners

Bucket Lips

Bulldozer Blades & Mold Boards

Coal Screens

Concrete Mixer Spiral Strips

Conveyor Buckets

Dredge Buckets

Dredge Pipe Reliners

Dredge Pumps

Dump Truck Beds

Fan Blades

Feed Grinding Mills

Foundry Shakeout Machines

Fresno Bottoms

Gravel Chutes

Gravel Screens

Conveyor Plates

Diesel Locomotive Wear Plates

Dragline Strips

Dragline Buckets and Strips (Bottoms and Sides, Heels and Shrouds)

Lips on Buckets

LHD Buckets

Off Skip Unloading Chutes

Ore Bin Conveyor Chutes

Ore Chutes

Pedestal & Journal Box Liners

Pug Mill Knives

Pug Mill Lining Plates

Pulp Wood Chutes

Quarry and Mine Skips

Quarry-Truck Liners

Reliners

Rollers

Roto Plates

Sand Blast Plates

Sand Chutes

Race Bars

Chain Drag Skid Bars

Wear Strips on Paving Machines

Reliner Bars for Crushers

Truck Bed Stripping Bars

Fan Housing Reliners

Snow Plough Shoes

Street Sweeper Shoes

Hoppers

Liner Plates

Log Conveyors

Mixer Blades

Mold Board (for Dozers)

Scrapers

Shaft Bin Chutes

Shot Blast Plates

Shovel Buckets

Skid Conveyors

Skip Car Plates

Sluice Pipes

Spouts

Steel Mill Equipment

Stone Chutes

Trailer Bottoms

Truck Bottoms

Underground Loading Pockets

Wear Plates

Wheelabrator Parts

Mine Digger Teeth

Trenching Machine Teeth

Tongs

Scarifier Teeth

Shovel Bucket Wear Bars

Chute Liner Strips

Chute Sides

Asphalt Dryer Wear Strips