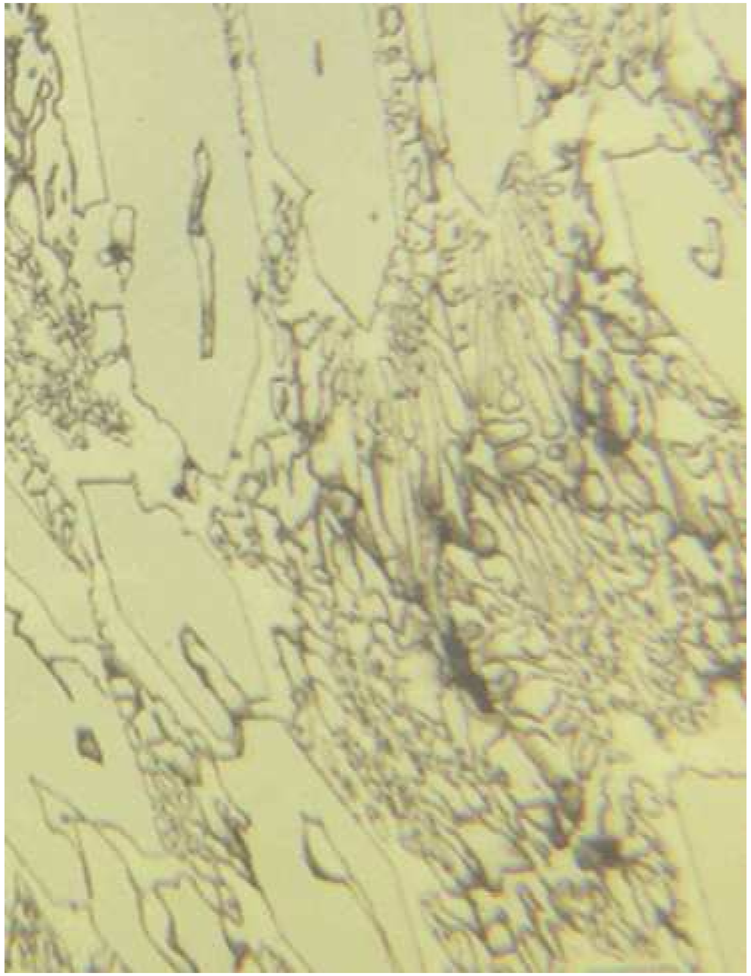


Triten™

A Guide to the Evaluation & Selection of

HARDFACED PLATE

Hardfaced or overlaid plate became commercially viable In 1965 when Roman F Arnoldy, founder of the Triten Corporation, invented and patented the bulk welding process. This invention enabled the economic deposition of a wear resistant chromium carbide alloy containing 4,5 – 5% carbon onto a ductile carbon steel base. Considerable refinement and development has taken place since then and today the range of overlaid plate available includes chromium and tungsten carbide grades with outstanding resistance to abrasion, erosion and impact at both ambient and elevated temperatures. In the majority of severe abrasion environments the chromium carbide alloys are the most economic solution.

Alloy Chemistry

The most commonly used alloy facing is a high chromium iron containing approximately one-third chromium and in excess of 4 percent combined carbon.
This corresponds to Triten T200X with a chemistry of:
C 5,4%, Mn 3,5%, Cr 34,0%, Others 1,3%, Balance Fe.
This standard alloy may be modified in a number of ways, to either increase abrasion resistance whilst reducing toughness, or vice versa. Conversely, the matrix may be hardened by reducing the manganese to 1 percent, with some loss in toughness. Further

refinement can be achieved by the introduction of other alloying elements. (See Triten Plate Range Summary for further details). ←tutaj ma być link do tego

Carbides

The material that gives high chromium iron alloys their ability to resist abrasion in the formation of primary carbides from a chemical compound of chromium, iron, and carbon, or chromium iron carbide, also called simply chrome carbide. Pure chromium carbide can be produced, but it is prohibitively expensive for large-area protection so Triten uses a mixed carbide of both chromium and iron, which exists as a primary carbide with the formula M_7C_3, where M indicates the mixture of iron and chromium in the compound.

Hardness

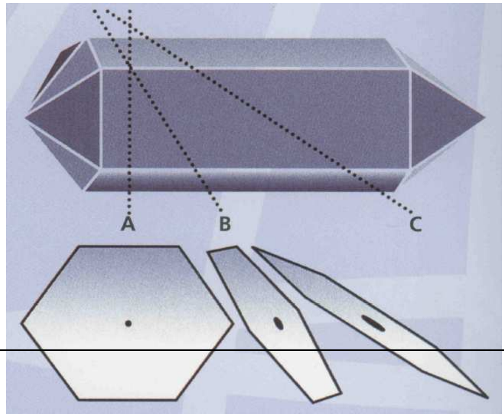
A typical (T200X) overlay alloy comprises a composite of chromium iron carbides in a matrix of a chromium iron carbon alloy. The hardness of primary chromium iron carbides is the equivalent of 1700HV compared with, for example, a typical workshop steel file, which has a hardness of 600HV. Generally the hardness of these alloys is measured using a Rockwell hardness tester, which although neither measure the carbide of the matrix, provides an acceptable general indication of the alloys hardness. A typical value being 54-60HRc.

Triten™

Evaluation & Selection of

HARDFACED PLATE

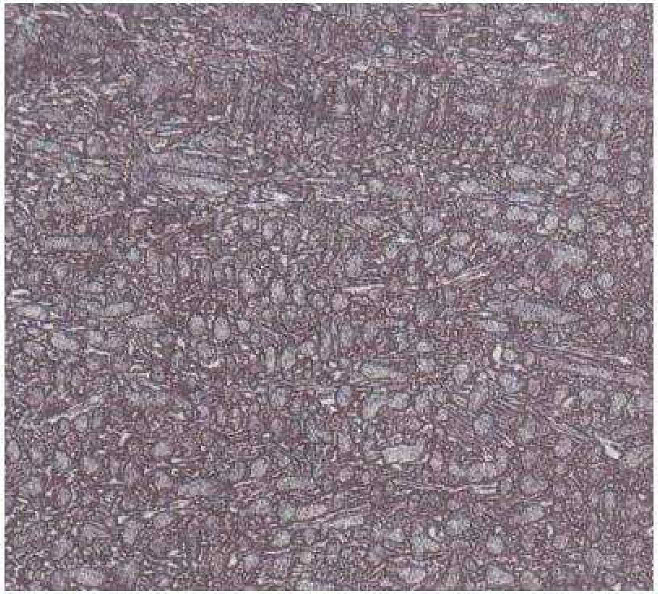
Microstructure



In addition to chemistry, the most important characteristic of the alloy overly is its microstructure. When viewed under a microscope the carbides will appear as white material against a dark background, the matrix. An ideal microstructure, for maximum abrasion resistance, will contain a dense arrangement of needle-like carbides, which in cross section appear as slender hexagons with a small hole in the centre.

The presence of irregulary shaped spots or avenues, as “fish bone patterns,” or as “ladders” having central poles with rungs on either side, in an indication that the carbon content is below optimum for maximum abrasion resistance but has increased impact resistant properties. See Triten Plate Range Summary for details of individual alloy formulations.

Micrographs typical of facings with different chemistry are illustrated bellow.



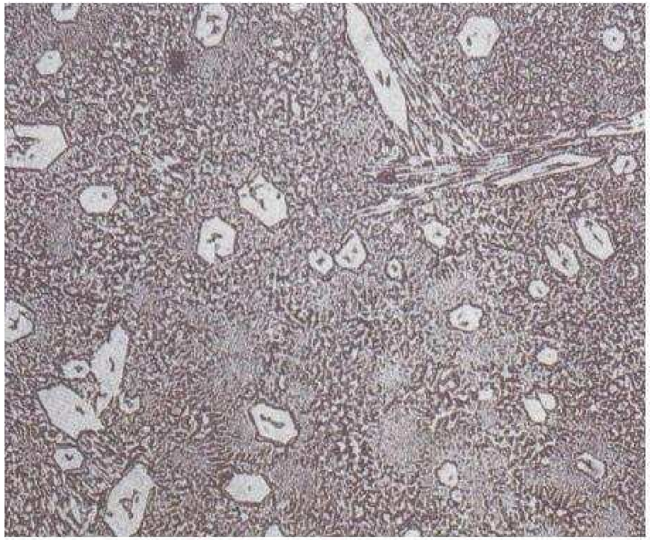
200x magnification
Average Hardness HRc 51,375

Primary carbides can be identified by their crystalline structure. When cut by a perpendicular plane, they appear hexagonal. Regardless of the angle of cut, the primary carbides usually appear with a black cavity near the centre, have sharp corners, and are crisply defined white structures against the dark matrix background.

Chemical Analysis

Carbon	2,88%	Chromium	16,7%
Manganese	2,03%	Molybdenum	<0,5%
Silicon	0,37%	Boron	0,62%

This micrograph shows an alloy of less than optimum composition in which there are no visible primary carbide structures. Much of the chromium content is visible as white specks in the matrix. Lesser carbides appear as round of fish bone structures. However, this type of alloy is suitable for high impact applications.



200x magnification
Average Hardness HRc 51,87

Chemical Analysis

Carbon	3,88%	Chromium	26,4%
Manganese	2,55%	Molybdenum	<0,05%
Silicon	0,51%	Boron	<0,50%

Increasing the carbon and chromium content results in the formation of primary carbide structures, which appear as lighter hexagonal forms in a darker matrix.

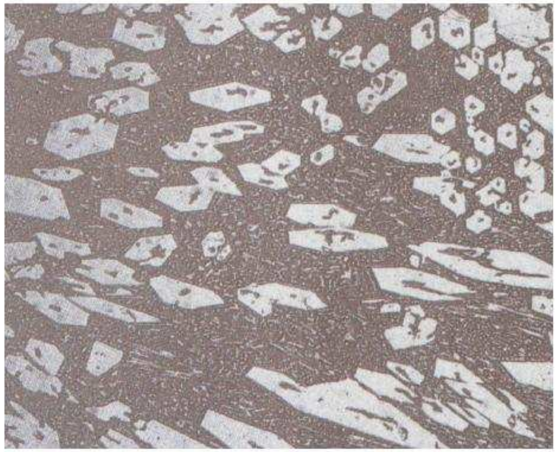
Note the easily visible cavity inside each crystalline-shaped primary carbide.

Chemical Analysis

Carbon	4,33%	Chromium	29,2%
Manganese	3,2%	Molybdenum	<0,05%
Silicon	0,43%	Boron	<0,50%

,8

This sample, the first that falls within the desirable 4-5 percent carbon range, shows better primary carbide development. Structures are easily distinguished from the dark matrix, with an excellent view of the appearance of primary carbides sliced crosswise (smaller hexagonal shapes), lengthwise (the longer needle-like shape, centre), and transversely (upper right, with the hollow centre shown as an elongated cavity). Density of the carbides within the matrix material is at the low end of the acceptable 35-to-45 percent range.

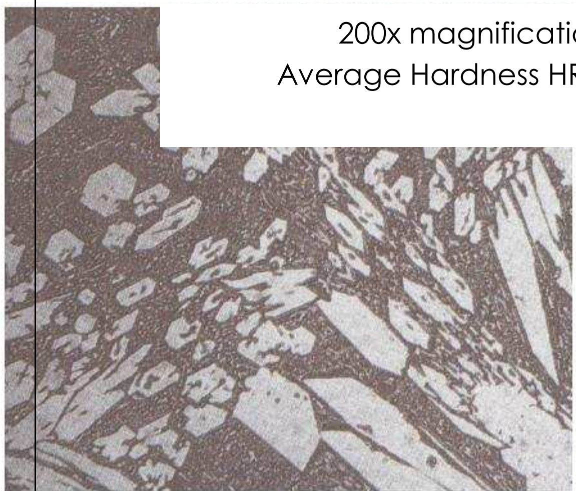


Chemical Analysis

Carbon	4,78%	Chromium	32,0%
Manganese	3,34%	Molybdenum	<0,05%
Silicon	0,47%	Boron	<0,50%

This micrograph shows the primary carbides as crisply defined and easily visible within the dark matrix material. Note the elongated appearance of the centre cavity of each primary carbide crystalline structure when it is sliced at an angle. Density is well within the desirable 35-to-45 percent range, with even distribution, which provides excellent wear characteristics.

200x magnification
Average Hardness HRc 58,6



Analysis

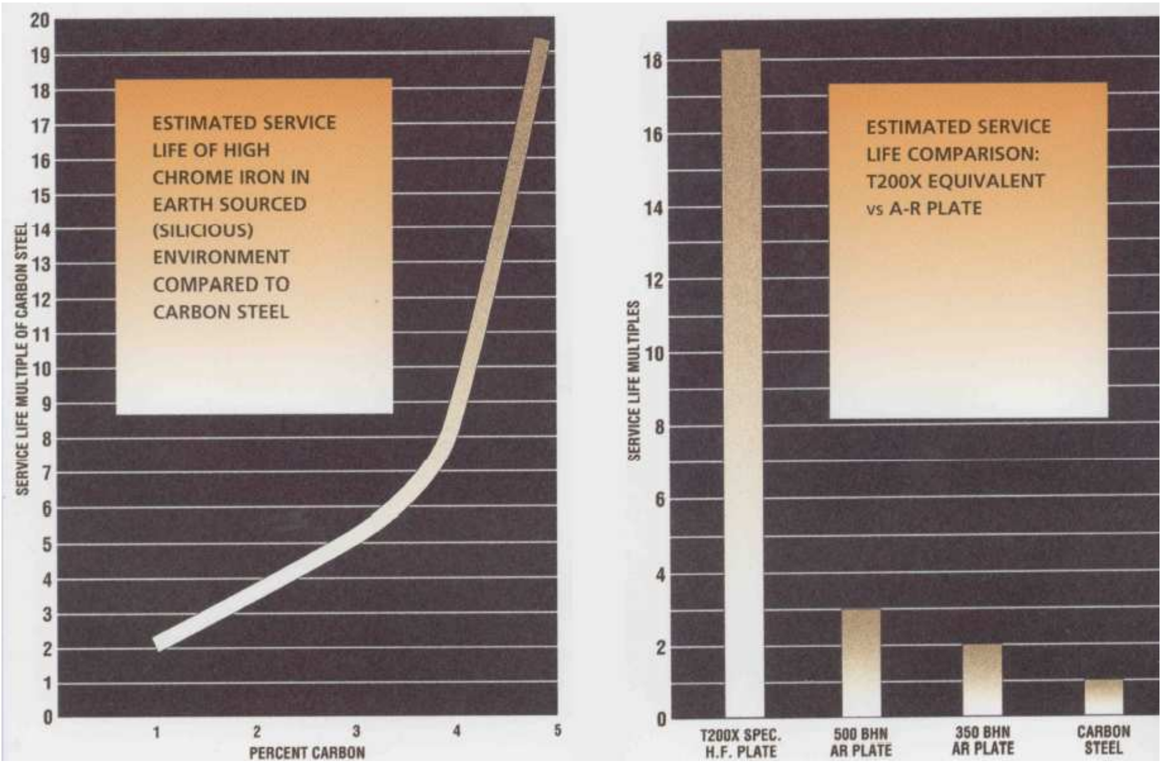
Carbon	4,84%	Chromium	31,6%
Manganese	3,09%	Molybdenum	<0,05%
Silicon	0,46%	Boron	<0,50%

In this final sample the primary carbide structures are at their maximum density, within the 35-to-45 percent range, creating an alloy with maximum wear resistance without excessive brittleness. There is still ample matrix material to hold the primary carbides in place. The patterns of crystalline growth, at right angles, are easily seen, along with the distinctive hexagonal crosscut shapes and the needle-like lengthwise shapes, each with a central cavity.

Note: See Triten Plate Range Summary (LINK TUTAJ ZROBIĆ), which provides details if the properties of each alloy formulation and its
59,8 suitability for particular service conditions.

Appearance

The appearance of an overlaid plate does not necessarily reflect its resistance to wear and it is often the less cosmetically attractive materials which have the better mechanical properties.
When the carbon content of the overlay goes beyond the 4 percent range, the facing becomes increasingly viscous and tends to be somewhat uneven. It may even contain some small holes that extend down to the base plate. For most uses this lack of smoothness is unimportant.
If a smooth surface finish is important for example when material flow is critical, smoother surfaces can be produced using the submerged arc welding process to deposit the overlay.



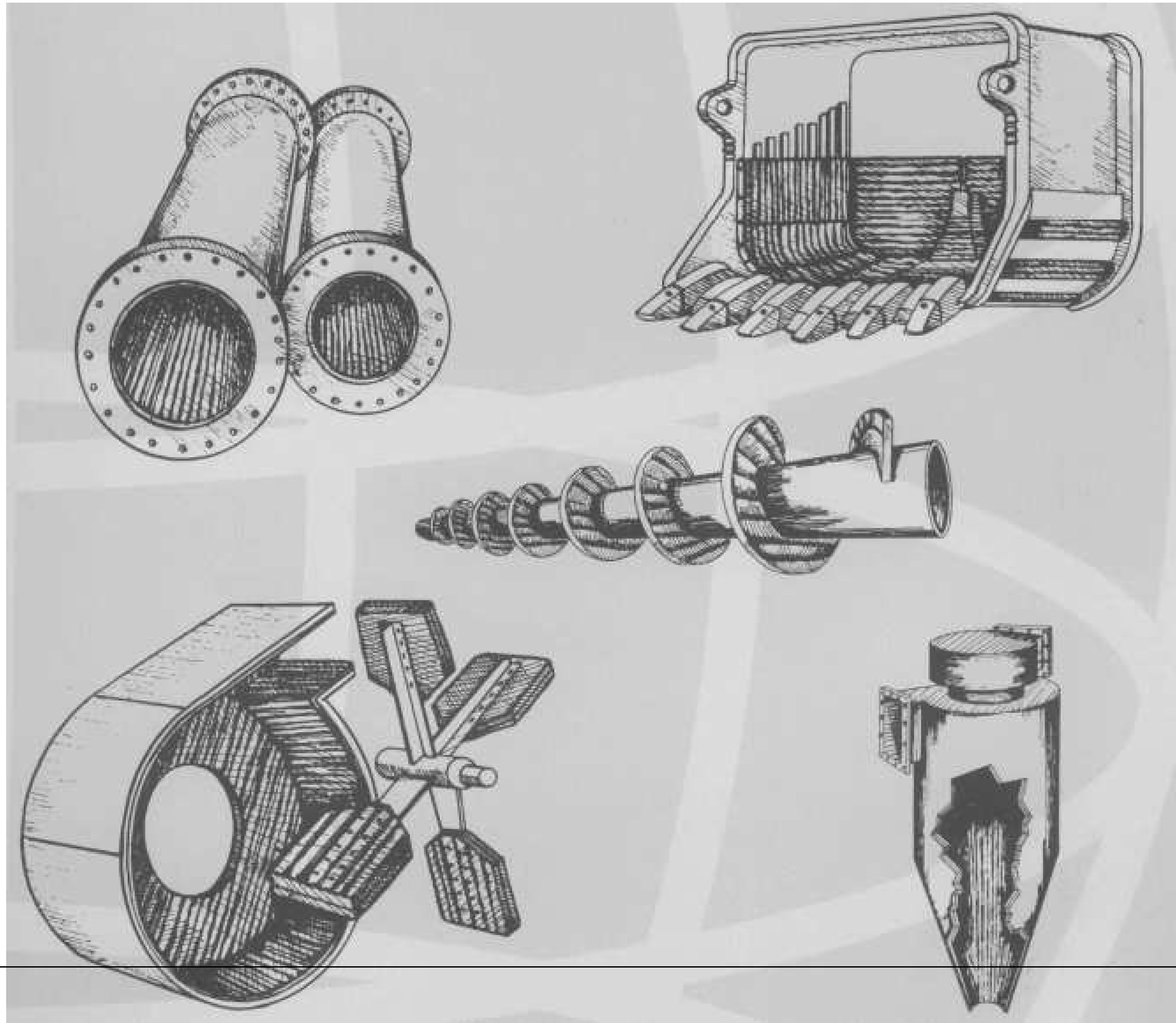
Cracks

Another characteristic of good quality plate is the presence of stress relief cracks which, contrary to first impression, are actually beneficial to this material. The presence of cracks in the hardfacing, at the correct frequency and spacing, allows the plate to be rolled, formed, and bend without damage. This characteristic is one of the basic features of Triten`s hardfaced plate patents.

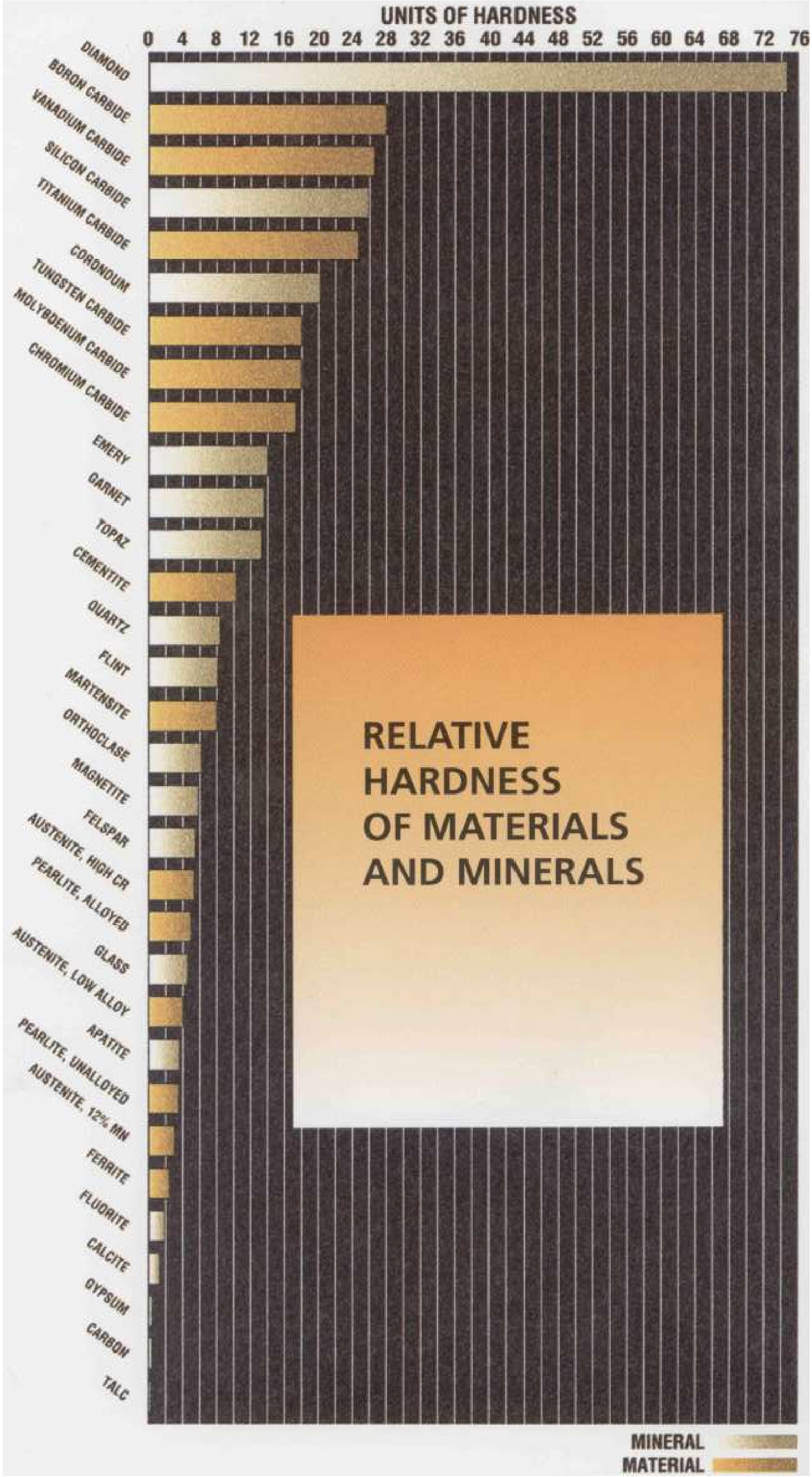
Applications

Triten T200X general purpose chromium carbide overlay plate typically can deliver up to 20 times the life of carbon steel. Combined with its versatility, this is the reason why T200X plate has become a great cost reducer in the manufacture of aluminium, asphalt, cement, glass, petrochemicals, power, pulp and paper, steel and synfuels, as well as in dredging, mining, oil refining, food and refuse processing, and numerous material – handling applications, such as scrap steel recycling.

The steel manufacturing industry, for example requires wear protection for hoppers, conveyor liners, and grizzly



bars that quickly rode without hardfacing protection.
In mining, without hardfacing protection, critical components such as chute liners, front-end-loader liners, end wear pads prematurely lose their usefulness due to the impact of silicious matter.
Refuse processing plants use overlay product in their hydra-pulper liners and beaters, screw conveyors and troughs, conical section wear liners, baler liners, tube liners, transfer points, flop gates, fan blades and liners and ash removal systems.



RELATIVE HARDNESS OF MATERIALS AND MINERALS
UNITS OF HARDNESS
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76
DIAMOND
BORON CARBIDE
VANADIUM CARBIDE
SILICON CARBIDE
TITANIUM CARBIDE
CORONDUM
TUNGSTEN CARBIDE
MOLYBDENUM CARBIDE
CHROMIUM CARBIDE
EMERY
GARNET
TOPAZ
CEMENTITE
QUARTZ
FLINT
MARTENSITE
ORTHOCLASE
MAGNETITE
FELSPAR
AUSTENITE, HIGH CR
PEARLITE, ALLOYED
GLASS
AUSTENITE, LOW ALLOY
APATITE
PEARLITE, UNALLOYED
AUSTENITE, 12% MN
FERRITE
FLUORITE
CALCITE
GYPSUM
CARBON
TALC
MINERAL
MATERIAL

Hardness Conversion Tables for Steels

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BRINELL		VICKERS	ROCKWELL		Shore	Tensile Strength (x 1000 psi)
Dia. (mm) 3000 Kg. 10mm. Carbide Ball	Hardness Number	Diam. Pyramid (50 Kg. Load)	C Scale 150 Kg. Brale	B Scale 150 Kg. 1/16" Ball		
2.25	745	840	65.3	....	91	....
2.30	712	....	....	....	....	....
2.35	682	737	61.7	....	84	....
2.40	653	697	60.0	....	81	....
2.45	627	667	58.7	....	79	....
2.50	601	640	57.3	....	77	....
2.55	578	615	56.0	....	75	....
2.60	555	591	54.7	....	73	298
2.65	534	569	53.5	....	71	288
2.70	514	547	52.1	....	70	274
2.75	495	528	51.0	....	68	264
2.80	477	508	49.6	....	66	252
2.85	461	491	48.5	....	65	242
2.90	444	472	47.1	....	63	230
2.95	429	455	45.7	....	61	219
3.00	415	440	44.5	....	59	212
3.05	401	425	43.1	....	58	202
3.10	388	410	41.8	....	56	193
3.15	375	396	40.4	....	54	184
3.20	363	383	39.1	....	52	177
3.25	352	372	37.9	(110.0)	51	171
3.30	341	360	36.6	(109.0)	50	164
3.35	331	350	35.5	(108.5)	48	159
3.40	321	339	34.3	(108.0)	47	154
3.45	311	328	33.1	(107.5)	46	149
3.50	302	319	32.1	(107.0)	45	146
3.55	293	309	30.9	(106.0)	43	141
3.60	285	301	29.9	(105.5)	....	138
3.65	277	292	28.8	(104.5)	41	134
3.70	269	284	27.6	(104.0)	40	130
3.75	262	276	26.6	(103.0)	39	127
3.80	255	269	25.4	(102.0)	38	123
3.85	248	261	24.2	(101.0)	37	120
3.90	241	253	22.8	100.0	36	116
3.95	235	247	21.7	99.0	35	114
4.00	229	241	20.5	98.2	34	111
4.05	223	234	(18.8)	97.3	....	....
4.10	217	228	(17.5)	96.4	33	105
4.15	212	222	(16.0)	95.5	....	102
4.20	207	218	(15.2)	94.6	32	100
4.25	201	212	(13.8)	93.8	31	98
4.30	197	207	(12.7)	92.8	30	95
4.35	192	202	(11.5)	91.9	29	93
4.40	187	196	(10.0)	90.7	....	90
4.45	183	192	(9.0)	90.0	28	89
4.50	179	188	(8.0)	89.0	27	87
4.55	174	182	(6.4)	87.8	....	85
4.60	170	178	(5.4)	86.8	26	83
4.65	167	175	(4.4)	86.0	....	81
4.70	163	171	(3.3)	85.0	25	79
4.80	156	163	(0.9)	82.9	....	76
4.90	149	156	....	80.8	23	73
5.00	143	150	....	78.7	22	71
5.10	137	143	....	76.4	21	67

(values in parentheses beyond normal range – for information only)