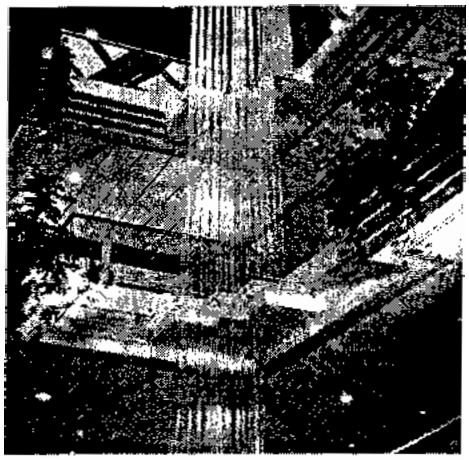
ALLPLASTICS
ARCHITECTURAL & BUILDING

Contact us
Tel. (02) 8038 2000 Fax. (02) 9417 6169
Web. www.allplastics.com.au
Address. Unit 20/ 380 Eastern Valley Way,
Chatswood, NSW 2067 AUSTRALIA.

Product Description

PLEXIGLAS® GS tubes
PLEXIGLAS® XT tubes

PLEXIGLAS XT tubes: Waterfall at the Warsteiner Brewery in Warstein, Germany



General remarks

PLEXIGLAS is an acrylic by the chemical name of polymethyl methacrylate (PMMA).
Tubes of PLEXIGLAS have the same outstanding properties as PLEXIGLAS sheets, blocks and rods.

They have
1. high-gloss surfaces, are
2. extremely light-transmitting,
3. uniquely age- and weather-resistant,

4. exceedingly break-resistant and
5. largely corrosion-resistant.

Tubes from PLEXIGLAS GS (= cast material)

Tubes cast from PLEXIGLAS GS are clear-transparent and UV-absorbing. Newly cast, they are smooth and glossy inside and dull on the outside. According to standard practice, their outside surfaces are polished, whereupon they become clear-transparent.

With the exception of tubes with an external diameter of 300 mm and wall thicknesses of 4 and 5 mm, all PLEXIGLAS GS tubes are somewhat more resistant to solvents (to be borne in mind for bonding).

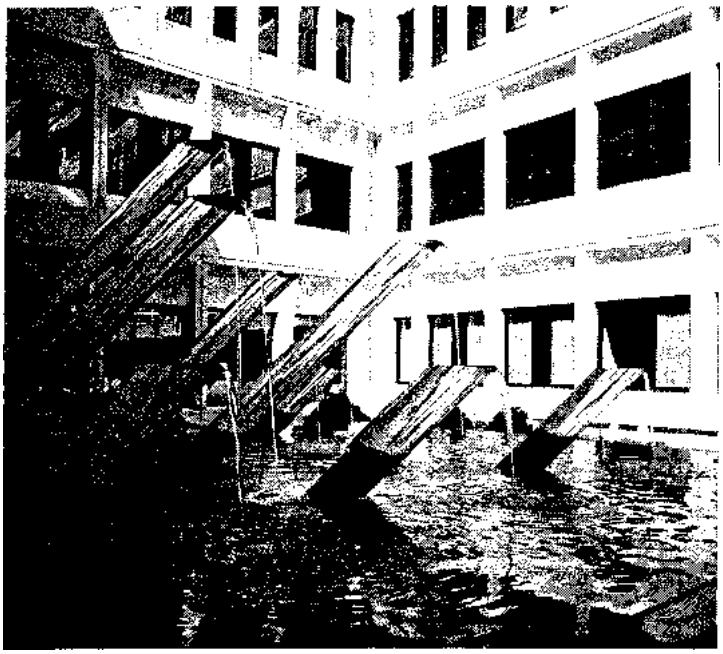
Tubes from PLEXIGLAS XT (= extruded material)

ALLPLASTICS
ARCHITECTURAL & BUILDING

Contact us
Tel. (02) 8038 2000 Fax. (02) 9417 6169
Web. www.allplastics.com.au
Address. Unit 20/ 380 Eastern Valley Way,
Chatswood, NSW 2067 AUSTRALIA.

Tubes extruded from PLEXIGLAS XT are clear-transparent and UV-transmitting and in certain sizes also available in white (UV-absorbing).
Their properties on short-term loading are largely the same as those of cast tubes of PLEXIGLAS GS. Their long-term behaviour is, however, somewhat less favourable.
The tubes are normally made from PLEXIGLAS 7H moulding compound (in Clear 29070 and White 053701. Slight extrusion lines are unavoidable.

PLEXIGLAS GS and XT tubes: Fountain



Material differences

Material	**PLEXIGLAS GS tube**	**PLEXIGLAS XT tube**
Manufacturing process	rotational casting	extrusion
Colour	clear-transparent	clear-transparent
Exterior surface	high gloss polish or dull	shiny with slight extrusion lines
Interior surface	smooth as glass	smooth as glass
Outside diameter (mm)	300... 650	5... 200
Wall thickness (mm)	4... 10	1... 5
Manufacturing length (mm)	2100... 3100	2000... 4000
Cold treatment	comparably good	comparably good
Bonding (after stress-relieving annealing)	with ACRIFIX® 190, 192 or 116	preferably with ACRIFIX® 116 and 117, but also with ACRIFIX® 190 or 192
Thermoforming	at c. 160 °C, formable when rubbery-elastic	at c. 150 °C, formable when soft-elastic
Resistance to chemicals and solvents	organic: limited alkaline: good	organic: limited alkaline: good

ALLPLASTICS
ARCHITECTURAL & BUILDING

Contact us
Tel. (02) 8038 2000 Fax. (02) 9417 6169
Web. www.allplastics.com.au
Address. Unit 20/ 380 Eastern Valley Way,
Chatswood, NSW 2067 AUSTRALIA.

Thermal stability

Permanent service temperature
The thermal stability of a finished part of PLEXIGLAS depends on many different factors: on the material grade, for example, the temperature and heating period, the wall thickness, the thermoforming method used, where applicable; and on additional stress factors like dead weight, load weight, etc. In figures, the thermal stability of these tubes can be described as follows:

Max. permanent service temperature (°C)	PLEXIGLAS GS	PLEXIGLAS XT
Long-term heating unformed	70 ... 90	70 ... 80
bent or expanded	70 ... 80	70 ... 80
Short-term heating unformed	80 [1] ... 100 [2]	80 ... 90
bent or expanded	80	80

[1] thin-walled
[2] thick-walled

Recommended applications

Tubes of PLEXIGLAS GS
1. Where particularly good transparency or aesthetic appearance (gloss) is required.
Examples: model building, precision engineering, exhibits.
2. Where bonding has to be performed.
3. Where tube diameters over 200 mm are needed.
4. Where transparent tubes are exposed to internal pressure.

Tubes of PLEXIGLAS XT
- particularly good value for money -
1. For tubes exposed to little internal pressure.
2. Where slight extrusion lines can be tolerated.
3. Where the required diameters are between 5 mm and 200 mm.
4. Where greater lengths are needed.
5. Where tubes are to be particularly easy to form (e.g. for dairy pipes).
6. Where white tubes (∅ 150 and 200 mm) are needed at short notice.

The water absorption of acrylic increases with the temperature. Permanent exposure to water at over 40 °C can cause tubes of PLEXIGLAS GS and especially PLEXIGLAS XT to turn milky-white. Provided the material has not been excessively stressed, this discolouration can be eliminated by drying in air or an oven.

Tubes exposed to internal pressure

Permissible internal pressure
The typical numerical values [*)] of the permissible internal pressure for the tubes included in our sales range are presented in the table (* please note).

ALLPLASTICS
ARCHITECTURAL & BUILDING

Contact us
Tel. (02) 8038 2000 Fax. (02) 9417 6169
Web. www.allplastics.com.au
Address. Unit 20/ 380 Eastern Valley Way,
Chatswood, NSW 2067 AUSTRALIA.

Available lengths:

PLEXIGLAS GS	2,100 to 3,100 mm, depending on ∅
PLEXIGLAS XT	2,000 and 4,000 mm, greater lengths on request

For **tolerances and other data**, please consult our "Sales Handbook, Semifinished Products".

The values were calculated according to the following equation which comes close to Mohr's formula:

$$p_{perm.} = \frac{2s(d_a - s)}{d_{a^2}} \bullet \sigma_{safe.}$$

σ_{safe} is the permissible tensile stress within the tube in the direction of the tangent to the circle, da the exterior diameter of the tube and s the wall thickness.
In the case of permanently stressed plastics a wide safety margin has to be allowed for. This is done by specifying a low value of σ_{safe}.

PLEXIGLAS GS	σ_{safe} = 4 MPa
PLEXIGLAS XT	σ_{safe} = 2.5 MPa

Compared with the pressure values which the technical inspection authorities establish for state-of-the-art pressure vessels (though not for those made of PMMA), the permissible internal pressures stated here are on the safe side.

These values apply to normal applications at temperatures **between - 40 °C and + 40 °C**. Adverse influences exerted by liquids, the environment or the method of installation, for example, are disregarded.

The tabulated values moreover apply to tubes **without** longitudinal seams. Thus, additional safety margins must be provided for tubes bonded in this way (e.g. by σ_{safe} = 1.5 MPa).

Fabricators can calculate the required minimum wall thicknesses for tubes of PLEXIGLAS GS and XT according to the following formula derived from the above equation:

$$s_{1,2} = \frac{d_a}{2} \pm \sqrt{\frac{d_{a^2}}{4} - \frac{p_{perm.} \bullet d_{a^2}}{2 \bullet \sigma_{safe}}}$$

Units:
1 MPa = 1 N/mm^2 = 10 bar

Table of typical values of the permissible internal pressure*)

*) The values were determined for the most unfavourable wall thicknes and outside diameter tolerances.

Diameter	Wall thickness	Weight	PLEXIGLAS GS tube	PLEXIGLAS XT tube

ALLPLASTICS
ARCHITECTURAL & BUILDING

Contact us

Tel. (02) 8038 2000 Fax. (02) 9417 6169
Web. www.allplastics.com.au
Address. Unit 20/ 380 Eastern Valley Way,
Chatswood, NSW 2067 AUSTRALIA.

outside	inside			permissible internal pressure
mm	mm	mm	kg/m	bar
5	3	1	0.015	6.7
6	3.5	1.25	0.022	7.2
6.5	4	1.25	0.024	6.7
7	5	1	0.022	5.0
8	4	2	0.044	8.7
10	7	1.5	0.047	5.6
	6	2	0.059	7.3
	4	3	0.078	10.0
12	10	1	0.041	3.1
	8	2	0.074	6.3
	6	3	0.100	8.9
13	10	1.5	0.064	4.5
	9	2	0.082	5.9
15	13	1	0.052	2.5
	11	2	0.096	5.6
	10	2.5	0.116	6.4
16	12	2	0.104	4.9
20	18	1	0.070	1.9
	16	2	0.133	4.0
	14	3	0.189	6.0
25	21	2	0.170	3.3
	19	3	0.245	4.9
30	26	2	0.207	2.8
	24	3	0.300	4.2
	22	4	0.385	5.5
	20	5	0.463	6.7
38	32	3	0.389	3.4
40	36	2	0.282	2.1
	34	3	0.411	3.3
	32	4	0.534	4.2
	30	5	0.648	5.2
50	46	2	0.356	1.7
	44	3	0.522	2.6
	42	4	0.682	3.5
	40	5	0.834	4.3
60	56	2	0.430	1.4
	54	3	0.634	2.1
	52	4	0.830	2.8
	50	5	1.019	3.6
70	64	3	0.745	1.9
	62	4	0.978	2.5
	60	5	1.204	3.1
80	74	3	0.856	1.6
	72	4	1.126	2.2
	70	5	1.389	2.7
90	84	3	0.967	1.4
	82	4	1.275	1.9
	80	5	1.575	2.4
100	94	3	1.078	1.3

ALLPLASTICS
ARCHITECTURAL & BUILDING

Contact us
Tel. (02) 8038 2000 Fax. (02) 9417 6169
Web. www.allplastics.com.au
Address. Unit 20/ 380 Eastern Valley Way,
Chatswood, NSW 2067 AUSTRALIA.

	92	4	1.423		1.7
	90	5	1.760		2.2
110	104	3	1.189		1.1
	100	5	1.945		2.0
120	114	3	1.301		1.0
	110	5	2.130		1.8
133	127	3	1.445		0.9
	123	5	2.371		1.7
150	144	3	1.634		0.8
	142	4	2.164		1.1
	140	5	2.686		1.4
180	172	4	2.608		0.9
200	194	3	2.190		0.6
	192	4	2.905		0.8
	190	5	3.613		1.1
300	292	4	4.387	0.8	
	290	5	5.465	1.1	
	288	6	6.536	1.4	
457	449	4	6.714	0.5	
	447	5	8.374	0.7	
	445	6	10.026	0.9	
	441	8	13.309	1.2	
650	640	5	11.941	0.5	
	638	6	11.313	0.6	
	634	8	19.033	0.8	
	630	10	23.706	1.0	

Mechanical treatment

Machining
Tubes of PLEXIGLAS GS and PLEXIGLAS XT can be milled, drilled, sawn, etc. with ease as long as suitable tools are used. They demand high cutting speeds and effective cooling, because as poor conductors of heat they show a tendency towards overheating and local buildup of thermal stress. Given pronounced friction, PLEXIGLAS XT in particular is inclined to gum and become sticky. Drilling should never be performed without using some water-miscible cooling lubricant (e.g. an emulsion).
Annealing may be required to eliminate internal stress in tubes of PLEXIGLAS GS and PLEXIGLAS XT .

Bonding
PLEXIGLAS GS and PLEXIGLAS XT can be bonded to themselves or with other materials. **Tubes to be bonded must be annealed beforehand**. Suitable adhesives are ACRIFIX® 116 or 117 for PLEXIGLAS XT (to itself) and ACRIFIX® 190 (or ACRIFIX® 192 for transparent items) especially for PLEXIGLAS GS, but also for XT and GS to XT.

A second annealing process after bonding will increase the strength and durability of the bond.

Thermoforming
Upon heating to the appropriate temperature, PLEXIGLAS GS (160 to 170 °C) and PLEXIGLAS XT (150 to 160 °C) become rubbery-elastic. The tubes can then be bent, stretched, expanded or blown up. Cooled down, they retain the new shape.

ALLPLASTICS
ARCHITECTURAL & BUILDING

Contact us
Tel. (02) 8038 2000 Fax. (02) 9417 6169
Web. www.allplastics.com.au
Address. Unit 20/ 380 Eastern Valley Way,
Chatswood, NSW 2067 AUSTRALIA.

Overheated PLEXIGLAS XT becomes viscous. Therefore special attention has to be paid to the correct forming temperatures. PLEXIGLAS GS tubes largely resume their original shape when heated again.

Especially with tubes of PLEXIGLAS XT, heating or thermoforming may cause optical distortion or blister formation through absorbed moisture. This can be avoided by pre-drying in an airflow oven at approx. 70 °C. The required drying time is about one hour per mm of wall thickness.

Hot bending of PLEXIGLAS tubes - which cannot be stuffed in the same way as metal pipes - is only possible at small diameters and large bending radii (radius > 5 x diameter). In order to prevent the tube wall from collapsing during free bending, a rubber hose or rubber rod may be introduced into the tube (see also Guidelines for Workshop Practice, "Thermoforming", Chap. 5.7).

Annealing
Annealing is a form of heat treatment **particularly advised for formed tubes** of PLEXIGLAS GS and XT. It is performed in airflow ovens at c. 80 °C for GS and c. 70 °C for XT. The annealing period should be at least 2 hours, and possibly longer, whereupon the parts are to be cooled down slowly in the switched-off oven. Annealing serves to eliminate stress in the material and to improve the quality of bonds, i.e. prevent crazing.

Tube connections

Screwed connections
Screwed connections are most widely used for beverage pipes. The fittings are usually made of metal, but plastics like polyamide, for example, are to be preferred. The tube ends are connected with the fittings by tapering, bonding or short-term heat treatment.

Flanged connections
Flanged connections are above all used for tubes of large diameters, for which no ready-made fittings are available. For exhibition purposes they are usually made of PLEXIGLAS GS, because of the special visual effect. Where flange and tube are to be bonded, special tubes of PLEXIGLAS XT have to be annealed before and after bonding to prevent crazing.

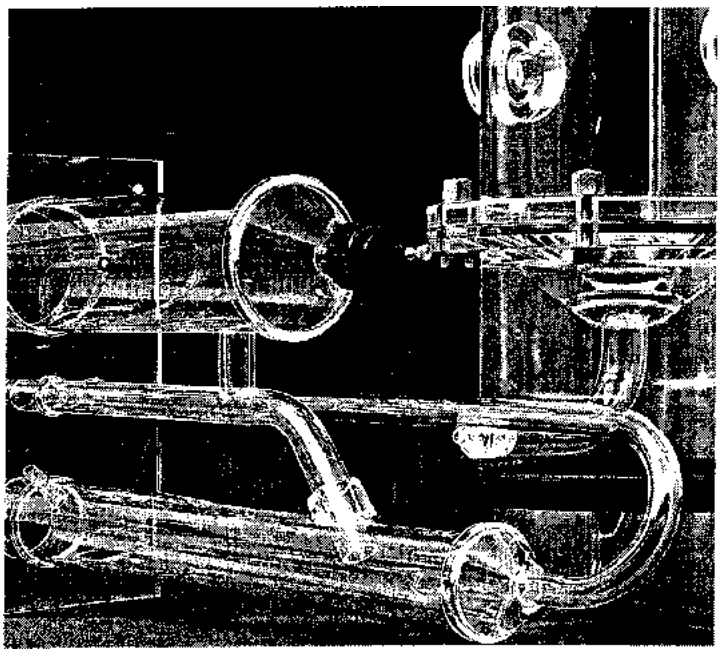
Scarfing
For producing scarf joints, one end of the tube is expanded while warm and pushed over the bevelled end of the other tube. It may then also be shrunk on. Tubes meant to be laid outdoors are best expanded in the workshop (making the "bell"). Sealing is performed either by filling the edge of the bell with ACRIFIX 190 adhesive, by applying PMMA-compatible silicone rubber as a sealant or by inserting a rubber sealing ring.

Bonding has certain disadvantages in this case: a clean bond can only be obtained in the workshop and the indispensable annealing process makes it a rather tedious procedure. Bonding on site is only possible with vertically installed tubes.

PLEXIGLAS GS and XT tubes: Partial view of the model of a laboratory-size clarifying plant

ALLPLASTICS
ARCHITECTURAL & BUILDING

Contact us
Tel. (02) 8038 2000 Fax. (02) 9417 6169
Web. www.allplastics.com.au
Address. Unit 20/ 380 Eastern Valley Way,
Chatswood, NSW 2067 AUSTRALIA.



Cleaning

Ordinary cleaning

Normally soiled PLEXIGLAS is washed down with water using a soft sponge. Very soft and non-linting glove lining fabric is the right material to use for wiping it dry. Dry rubbing with any kind of cloth may cause scratches. Obstinate dirt and especially grease on the surface can normally be removed with a mild dishwashing liquid, warm soap suds or soda water.
An excellent product is the ANTISTATIC CLEANING AGENT by BURNUS.

Chemical cleaning

Chemical cleaning is performed where mechanical cleaning is either impossible or inexpedient, e.g. on the inside of beverage pipes.

Suitable for this purpose are alkaline solutions and dilute acids, which may be heated to 40-50 °C. Chemicals for cleaning beverage pipes, containers and the like are:

CALGONIT D, DA, S	Joh. A. Benckiser GmbH, Ludwigshafen
P 3®, P 3- Grundreiniger, P 3-dix	Henkel & Cie. GmbH, Düsseldorf

Preventing dust attraction

Like other electrically well-insulating plastics, PLEXIGLAS GS and PLEXIGLAS XT are electrically charged by friction, which results in dust attraction. This can be prevented by wiping PLEXIGLAS with the ANTISTATIC CLEANING AGENT by BURNUS. Unless this layer is washed or wiped off, the antistatic effect is retained for a long time depending on the atmospheric humidity, the air temperature and air flow.

PLEXIGLAS GS tubes: Fountains in front of the BfA in Nuremberg

ALLPLASTICS
ARCHITECTURAL & BUILDING

Contact us
Tel. (02) 8038 2000 Fax. (02) 9417 6169
Web. www.allplastics.com.au
Address. Unit 20/ 380 Eastern Valley Way,
Chatswood, NSW 2067 AUSTRALIA.

Terms of delivery according to our latest sales range, Semifinished Products. General information on the properties of our materials is given in separate leaflets, which are available from your stockist.
With the publication of this information, earlier issues of the same have lost their validity.

Our technical advice on the uses of our materials is given without obligation. The buyer is responsible for the application and processing of our products and is also liable for observing any third-party rights. Technical data concerning our products are typical values. Subject to alteration.

®= registered trademark

PLEXIGLAS® = registered trademark of Röhm GmbH, Darmstadt

ACRIFIX® = registered trademark of Röhm GmbH, Darmstadt

Important notice
This is an international English-language information prepared for several markets.
It is essential that the selection of particular materials and their methods of use conform with the requirements of national and local Building Regulations.
The availability of any particular product should be checked with your supplier.

ALLPLASTICS
ARCHITECTURAL & BUILDING

Contact us
Tel. (02) 8038 2000 Fax. (02) 9417 6169
Web. www.allplastics.com.au
Address. Unit 20/ 380 Eastern Valley Way,
Chatswood, NSW 2067 AUSTRALIA.

Tubes exposed to internal pressure

Permissible internal pressure

The numerical values* of the permissible internal pressure for the tubes included in our sales range are presented in the table opposite.
(* please note)
Available lengths (mm):

PLEXIGLAS GS	2,100 to 3,100 depending on Ø
PLEXIGLAS XT	2,000 and 4,000 greater lengths on request

For **tolerances and other data,** please consult our "Sales Handbook, Semifinished Products."
The values were calculated according to the following equation which comes close to Mohr's formula:

$$p_{perm.} = \frac{2\,s\,(d_a - s)}{d_a^2} \cdot \sigma_{safe.}$$

σ_{safe} is the permissible tensile stress within the tube in the direction of the tangent to the circle, d_a the exterior diameter of the tube and s the wall thickness.
In the case of permanently stressed plastics a wide safety margin has to be allowed for. This is done by specifying a low value of σ_{safe}.

PLEXIGLAS GS:	$\sigma_{safe} = 4$ MPa
PLEXIGLAS XT:	$\sigma_{safe} = 2.5$ MPa

Compared with the pressure values which the technical inspection authorities establish for state-of-the-art pressure vessels (though not for those made of PMMA), the permissible internal pressures stated here are on the safe side.

These values apply to normal applications at temperatures **between −40 °C and +40 °C.** Adverse influences exerted by liquids, the environment or the method of installation, for example, are disregarded.

The tabulated values moreover apply to tubes **without** longitudinal seams.
Thus, additional safety margins must be provided for tubes bonded in this way (e.g. by $\sigma_{safe} \approx 1.5$ MPa).

Fabricators can calculate the required minimum wall thicknesses for tubes of PLEXIGLAS GS and XT according to the following formula derived from the above equation:

$$s_{1,2} = \frac{d_a}{2} \pm \sqrt{\frac{d_a^2}{4} - \frac{p_{perm.} \cdot d_a^2}{2 \cdot \sigma_{safe}}}$$

Units:
1 MPa = 1 N/mm^2 = 10 bar

Diameter outside	Diameter inside	Wall thickness	Weight	**PLEXIGLAS GS tube** permissible internal pressure	**PLEXIGLAS XT tube** permissible internal pressure
mm	mm	mm	kg/m	bar	bar
5	3	1	0.015		6.7
6	3.5	1.25	0.022		7.2
6.5	4	1.25	0.024		6.7
7	5	1	0.022		5.0
8	4	2	0.044		8.7
10	7	1.5	0.047		5.6
	6	2	0.059		7.3
	4	3	0.078		10.0
12	10	1	0.041		3.1
	8	2	0.074		6.3
	6	3	0.100		8.9
13	10	1.5	0.064		4.5
	9	2	0.082		5.9
15	13	1	0.052		2.5
	11	2	0.096		5.6
	10	2.5	0.116		6.4
16	12	2	0.104		4.9
20	18	1	0.070		1.9
	16	2	0.133		4.0
	14	3	0.189		6.0
25	21	2	0.170		3.3
	19	3	0.245		4.9
30	26	2	0.207		2.8
	24	3	0.300		4.2
	22	4	0.385		5.5
	20	5	0.463		6.7
38	32	3	0.389		3.4
40	36	2	0.282		2.1
	34	3	0.411		3.3
	32	4	0.534		4.2
	30	5	0.648		5.2

* The values were calculated for the most unfavourable wall thicknesses and the diameter tolerances