



شرکت ملی گاز ایران - مدیریت پژوهش و فناوری

امور تدوین استانداردها

IGS

Iranian Gas Standards

مشخصات فنی خرید

لوله های پلی اتیلن

P.E. PIPES part(1)



تاریخ: ۸۸/۹/۴
شماره: گ. ۱۰/دب. ۱۰/۷۶۶ - ۱۵۲۱۰



شرکت ملی گاز ایران

دفتر مدیرعامل



ابلاغ مصوبه هیأت مدیره

مدیر محترم پژوهش و فناوری

باسلام،

به استحضار می‌رساند در جلسه ۱۳۷۹ مورخ ۱۳۸۸/۷/۷ هیأت مدیره، نادمه شماره

گ. ۸۲۴۵۰/۱۰۰۰/۹ مورخ ۸۸/۶/۲۸ آن مدیریت در مورد تصویب نهایی استاندارد تحت عنوان

"لوله های پلی اتیلن (بخش ۱)" به شماره استاندارد P.E.Pipes(part1) IGS-M-PL-014-1(2)

مطرح و مورد تصویب قرار گرفت.

ناصر آنگون

دبیر هیأت مدیره

رونوشت: مدیرعامل محترم شرکت ملی گاز ایران و قائم مقام رئیس هیأت مدیره

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1. Scope

1.1. This standard specification **Cancels and replaces IGS-MP-014-1(1)** and provides NIGC'S requirements for material, manufacturing, testing, inspection, dimension, tolerances, marking, packing, handling, storage, transportation and etc, for polyethylene pipes in accordance with CEN specification EN 1555– 2: 2008 edition and ISO 4437: 2004 edition for PE 80 or PE 100, SDR 11 or SDR 13.6 respectively at maximum operating pressure of 4 bar.

This standard covers two types of pipe:

- PE pipes (outside diameter dn) including four yellow identification stripes
- PE pipes (outside diameter dn) with a peelable, thermoplastics PP material additional layer on the outside of the pipe ('coated pipe') as specified in Annex A.

2. References

Through out this standard specification the following standards and codes are referred to, the edition of these standards and codes that are in effect at the time of issues of this standard specification.

The applicability of changes in standards and codes that occur after the date of standards that referred shall be mutually agreed upon by the purchaser and supplier / or manufacturer.

2.1. Normative references:

- | | |
|----------------------|--|
| BS 6730 , 1986 | : Black polyethylene up to nominal size 63 for above ground use for cold portable eater. |
| EN 1056 , 1996 | : Plastics piping and ducting systems – plastics pipes and fittings – method for exposure to direct (natural) weathering . |
| EN 1555-1, 2008 | : Plastics piping systems for the supply of gaseous fuels– polyethylene (PE) – part 1: general . |
| EN 1555-2, 2008 | : Plastic piping systems for the supply of gaseous fuels- Polyethylene (PE)-pipes. |
| EN 1555-5, 2008 | : Plastics piping systems for the supply of gaseous fuels– polyethylene (PE) – part 5: fitness for purpose of the system. |
| EN ISO 1133,2005 | : Plastics - determination of the melt mass – flow rate (MFR) and the melt volume – flow rate (MVR) of thermoplastics |
| EN ISO 3126 ,1999 | : Plastics piping systems – plastics piping components – measurement and determination of dimensions |
| EN ISO 6259-1,1997 | : Thermoplastic pipes-Determination of tensile properties-Part 1: General test method |
| EN ISO 6259-3 , 1997 | : EN ISO 6259-3, Thermoplastic pipes-Determination of tensile properties-Part 3: Polyolefin pipes |
| ISO 13477 , 2007 | : Thermoplastics pipes for the conveyance of fluids – determination of resistance to rapid crack propagation (RCP) – small scale steady state test (S4 test) |
| EN ISO 13478 , 2007 | : Thermoplastics pipes for the conveyance of fluids – determination of resistance to rapid crack propagation (RCP) –full scale test |
| EN ISO 13479, 2007 | : Polyethylene pipes for the conveyance of fluids – determination of resistance to crack propagation – test method for slow crack growth on Notched pipes |

	(notch test)
EN ISO 2505 ,2005	: Thermoplastics pipes – longitudinal reversion – test method and parameters
EN ISO 1167-1,2006	: Thermoplastics pipes, fittings and assemblies for the conveyance of fluids – determination of fluids – determination of the resistance to internal pressure – part 1: general method
EN ISO 1167-2,2006	: Thermoplastics pipes, fittings and assemblies for the conveyance of fluids – determination of the resistance to internal pressure part 2: preparation of pipe pieces
GIS/PL2-2 ,2008	: Polyethylene pipes and fittings for natural gas and suitable manufactured gas Part 2 : pipes for use at pressures up to 5.5 bar
ISO 1183	: plastics – methods for determining the density and relative density of non-cellular plastic
ISO 4437 ,2004	: Buried poly ethylene (PE) pipes for the supply of gaseous fuels-metric series-specifications.
ISO FDIS 11357-6:2002	: plastics – differential scanning calorimetry (DSC) – part 6: determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)
ISO 13480 ,1997	: Polyethylene pipes – resistance to slow crack growth – cone test method

3. Definition

3.1. Batch release test (BRT)

Test performed by the manufacturer on a batch of material or components which has to be satisfactorily completed before the batch can be released.

3.2. Lower predicted limit of the predicted hydrostatic strength σ_{LPL}

Quantity with dimension of stress, which represents the 97.5% lower confidence limit of the predicted hydrostatic strength for a single value at a temperature T and a time t. It is denoted as: $\sigma_{LPL} = \sigma(T, t, 0,975)$

3.3. Minimum required strength MRS

Value of σ_{LPL} at a temperature of 20°C and a time of 50 years ($\sigma(20,50\text{years}, 0,975)$), rounded down to the next smaller value of the R10 series or of the R20 series conforming to ISO 3, ISO 497 and ISO 12162 , depending on the value of σ_{LPL}

3.4. Melt mass flow rate, MFR:

A value relating to the viscosity of the molten material at a specified temperature and rate of shear.

3.5. Peelable pipe

Pipe made with polyethylene core material over which is an outer skin, which is removed locally with the aid of simple tools, prior to fusion jointing

3.6. Core pipe

Polyethylene pipe without skin

Note : the core meets all the dimensional requirements of this standard

3.7. Pipe batch

Number of linepipes , all of same nominal outside diameter , wall thickness and marking , extruded from the same compound on the same machine . The pipe batch is defined and identified by the pipe manufacturer.

3.8. Type testing (TT)

Testing performed to prove that the material, component, assembly is capable of conforming to the requirements given in the relevant standard.

In addition, relevant type tests shall be carried out and relevant certificate shall be submitted when ever there is a change in design, and /or in the production method other than routine in – process adjustment and any change in raw material such as brand , production designation , production location . In case of no changes in mentioned above items every five years the type tests certificate shall be renewed.

4. General characteristic

4.1. Material

Raw material shall be acc. To EN 1555-1

4.2. Compound (In the form of granules)

The pipe with minimum density (0.945 g/cm³), melt flow index (0.2-0.7) gr/10 min. , carbon black content (2 to 2.5 %) , SDR 11 or SDR 13.6 , PE 80 or PE 100 respectively. shall be made from virgin material. Processed PE material (ie. recycled material, reused material) and any master batch or other additives are not allowed. Any changes in the choice of materials shall require a new qualification of the pipe according to table 3.

4.3. Identification stripes

These stripes shall be yellow and 90 degree apart and shall be manufactured from PE base polymer as used for the PE pipe.

5. Appearance

The internal and external surfaces of pipes shall be smooth and clean and have no scoring, cavities and other surface defects such as grain, blister, scratch. The pipe ends shall be cut cleanly and square to the axis of the pipe.

5.1. Color

Pipes shall be black with 4 yellow identification stripes

6. Dimension

The minimum wall thickness and pipe outside diameter, length and tolerances shall conform to table 1

Table 1

Nominal size DN/OD (mm)	Minimum Mean Outside diameter (mm)	Maximum Mean Outside diameter (mm)	Maximum out-of-roundness (mm) ^{ab} (straight pipe)	Wall thickness tolerances				PIPE LENGTH (m)	DIMENSIONS OF STRIPS For polyethylene ^e	
				MIN. W.T (mm)		Tolerance on wall thicknesses			Coil ^d /STRAIGHT ^e	WIDTH (mm)
				SDR 11	SDR 13.6 ^c	PLUS Tolerance SDR 11	PLUS Tolerance SDR 13.6			
25	25.0	25.3	1.2	3		0.4		100 (COIL)	3-5	MAX 10% OF W.T
32	32.0	32.3	1.3	3		0.4		100 (COIL)	3-5	
63	63.0	63.4	1.5	5.8	4.7	0.7	0.6	100 (COIL)	3-5	
90	90.0	90.6	1.8	8.2	6.7	1.0	0.8	50 (COIL)	5-10	
110	110.0	110.7	2.2	10	8.1	1.2	1.0	50 (COIL) or 12(STRAIGHT)	5-10	
125	125.0	125.8	2.5	11.4	9.2	1.3	1.1	12 (STRAIGHT)	5-10	
160	160.0	161.0	3.2	14.6	11.8	1.6	1.3	12 (STRAIGHT)	5-10	
200	200.0	201.2	4.0	18.2	14.7	2.0	1.6	12 (STRAIGHT)	5-12	
225	225.0	226.4	4.5	20.5	16.6	2.2	1.8	12 (STRAIGHT)	5-12	

a- Measurement of out of roundness shall be made at the stage of manufacturing

b- The maximum ovality (out of roundness) for coiled / drum pipes shall not exceed the value of 6% of OD.

Nevertheless during the welding process, the maximum ovality in fusion zone shall not exceeds the value of 1.5% of OD

c- SDR 13.6 just for PE 100 material

d- Coiled pipe length tolerance $\pm 10\%$

Otherwise, shall be agreed by purchaser and manufacturer and not more than 10 percent of total number of coil which is related to purchase order

e- Straight pipe length tolerance $\pm 1\%$

7. Batch quantity with considering to each production line per each extruder or maximum duration of one week shall be according to table 2

Table 2 (batch quantity)

OD	Straight pipe Total length (km)	Coiled pipe (quantity)
25	-	400
32	-	400
63	-	300
90	-	200
110	10	200
125	10	-
160	10	-
200	8	-
225	8	-

8. Required characteristics

Pipe shall have characteristics conforming to requirements given in table 3

Table 3

Characteristic	Requirements	Test parameters		Test method	Type of test
		Parameter	Value		
Hydrostatic Strength ^a (20 ^o C , 100h)	No failure during the test period of any test piece	End caps orientation conditioning time at test temperature number of test pieces ^b type of test circumferential (hoop) stress for : PE 80 PE100 Test period Test temperature	Type a) Free Shall conform to ISO 1167-1 3 Water in water 10 MPa 12,4 MPa 100h 20 ^o C	ISO 1167-1/2 (2006)	TT
Squeeze- off followed by hydrostatic Strength ^a (80 ^o C , 165h)	No failure during the test period of any test piece ^c	End caps orientation conditioning time at test Temperature number of test pieces ^b type of test circumferential (hoop) stress for : PE 80 PE100 Test period Test temperature	Type a) Free Shall conform to ISO 1167-1/2 3 Water in water 4,5 MPa 5,4 MPa 165h 80 ^o C	Squeeze - of according to Annex C of EN 1555-2 (2008) ISO 1167-1/2 EN 12106 (2006)	BRT
Squeeze – off followed by	No failure during the test	End caps orientation	Type a) Free	Squeeze - of	

hydrostatic Strength ^a (80°C , 1000h)	period of any test piece	conditioning time Temperature number of test pieces ^b type of test circumferential (hoop) stress for : PE 80 PE100 Test period Test temperature	Shall conform to ISO 1167-1/2 3 Water in water 4 MPa 5 MPa 1000h 80°C	according to Annex C of EN 1555-2 (2008) ISO 1167-1/2 EN 12106 (2006)	TT
Elongation at break ^d	≥400%	Speed of testing : e<13mm e≥13mm Test piece dimension Number of test pieces ^b	100mm/min 25 mm/min Shall conform to ISO 6259-3 ^e Shall conform to EN ISO 6259-1	EN ISO 6259-1 ^f and ISO 6259-3	TT BRT
Resistance to slow crack growth for e ≤5 mm (cone test)	v≤10mm/ day	Number of test pieces ^b	Shall conform to ISO 13480	ISO 13480	TT

(continued)

Table 3 (Continued)

Resistance to slow crack growth for e >5 mm (notch test)	No failure during the test period	Test temperature internal test pressure : PE80 , SDR 11 PE100 , SDR 11 PE100,SDR13,6 Test period Type of test Number of test pieces ^b	80°C 8 bar 9,2 bar 7,3 bar 500 h Water in water Shall conform to EN ISO 13479	EN ISO 13479	TT
Resistance to rapid crack propagation (critical pressure , pc) ^g	Pc ≥1.5MOP with Pc = 3.6 Pc,s4 +2.6 ⁱ	Test temperature number of test pieces ^b	0°C Shall conform to ISO 13477	ISO 13477	TT
Resistance to short-time hydraulic pressure (quick burst test)	Ductile failure (minimum burst pressure 32 bar)	Test temperature	23±2 ⁰ C	ASTM D1599 Procedure B	TT BRT
Conventional density conforming to EN ISO 1872 -1	≥945 kg /m ³ (base polymer)	Test temperature number of test pieces ^b	23 ⁰ C Shall conform to ISO 1183	EN 1183-1/2	TT BRT
Oxidation induction time	>25min >50 min	Test temperature	210 ⁰ C ^j 200 ⁰ C	ISO 11357-6	TT BRT

(thermal stability) ^h		number of test pieces ^{b n}	3		
Melt mass – flow rate (MFR)	0.2 ≤MFR≤0.7 g/10 min	Loading mass test temperature time number of test pieces ^b	5 kg 190 ^o C 10min Shall conform to EN ISO 1133	EN ISO 1133	TT BRT
Longitudinal reversion	≤3% Original appearance of the pipe shall remain	Test temperature length of test piece immersion time Test method Number of test pieces ^b	110 ^o C 200 mm 1 h Free Shall conform to EN ISO 2505	EN ISO 2505	TT BRT
Carbon black content ^l	(2 to 2.5)% (by mass)	Shall conform to ISO 6964		ISO 6964	TT
Carbon black dispersion ^l	Grade ≤ 3	Preparation of test pieces number of test pieces ^b	Free ^m shall conform to ISO 18553	ISO18553	TT BRT

a- This characteristic shall be also considered when using the squeeze – off technique (see annex C of EN 1555 – 2 :2008)

b- The numbers of test pieces given indicate the numbers required to establish a value for the characteristic described in the table.

The numbers of test pieces required for factory production control and process control should be listed in the manufacturer's quality plan. For guidance see CEN/TS 1555-7

c- Only brittle failures shall be taken in to account. If a ductile failure occurs before 165 h, the test may be repeated at a lower stress. The stress and the associated test period shall be selected from table 3 or from a line based on the stress time points given in table 4.

d- Where the rupture takes place outside the gauge marks, is accepted if the value conforms to the requirements.

e- The test can be terminated when the requirement is met, without necessarily carrying out the test up to rupture of the test pieces.

f- Where practical, machine or die cut type 2 test pieces may be used for pipe wall thickness equal to or less than 25 mm.

g- Rapid crack propagation testing is only required when the wall thickness of the pipe is greater than the wall thickness of the pipe used in the rapid crack propagation PE compound test (see table 2 of EN 1555-1:2008).

h- Before sampling for oxidation induction time test, 0.2 mm from the surface should be taken off.

i- Full scale /S4 correlation factor is equal to 3.6 and is defined as the full scale /S4 critical absolute pressures ratio.

Note: attention is drawn to the fact that the correction factor may be modified, when revising this standard, according to the result of work of ISO, TC 138/SC4 plastics pipes, fitting and valves for the supply of gaseous fuels.

If the requirement is not met of S4 test equipment not available, then (re) testing by using the full scale test shall be performed in accordance whit EN ISO 13478. In this case: PC= PC₁ full scale.

j- Test may be carried out at 210^oC providing that there is a clear correlation with the results at 200^oC . In case of dispute the reference temperature shall be 200^oC.

l- Only for black compound

m- In case of dispute, the test pieces shall be prepared by the compression method.

- n- Samples shall be taken from the outer and inner pipe surface. Samples from weathered pipes at the outside weathered surface shall be taken from surfaces prepared as for joining (EN 1555-5; 2008)

9. Retest in case of failure at 80°C

A fracture in a brittle mode in less than 165 h shall constitute a failure, however if a sample in the 165 h test fails in a ductile mode in less than 165 h, a retest shall be performed at a selected lower stress in order to achieve the minimum required time for the selected stress obtained from the line through the stress / time points given in table 4.

Table 4- test parameters for the retest of hydrostatic strength at 80°C

PE 80		PE 100	
Stress MPa	Test period h	Stress MPa	Test period h
4,5	165	5,4	165
4,4	233	5,3	256
4,3	331	5,2	399
4,2	474	5,1	629
4,1	685	5,0	1000
4,0	1000	--	--

10. Marking

Marking details shall be printed or formed directly on the pipe in such a way that the marking does not initiate cracks or other types of failure.

Under normal storage, weathering and processing conditions, utilizing the permissible method of installation and use, legibility shall be maintained for the life of the pipes.

If printing is used, the coloring of the printed information shall differ from the basic coloring of the product. (Preferably white / yellow)

The quality and the size of the marking shall be such that it is easily legible without magnification.

All pipes shall be marked with the data given in table 5

The frequency of the printing shall be at intervals not greater than 1m

Table 5

Marking requirement

Aspect	Marking
Manufacturer name or trademark	Name or symbol
Internal fluid	Natural gas
For pipes <i>w.t.</i> ≤ 3,0 mm: - Nominal outside diameter × wall thickness For pipes <i>w.t.</i> > 3,0 mm: - <u>Nominal outside diameter</u> - <u>Pipe series</u>	($d_n \times w.t.$)* d_n SDR
Material designation	PE 80 or PE 100
Type of pipe	e.g ordinary or peelable layer

Production date	Year / month / day
IGS Standard NO.	IGS –M- PL -014-(2)
National Iranian Gas Co. symbol	NIGC

* for pipe with $d_n=25$

Peelable pipe shall be marked accordingly including any specific instructions related to these types

11. Packaging

At all times , PE pipes should be stored so as to minimize the possibility of the material being damaged by crushing , piercing or extended exposure to direct daylight (maximum one month) straight pipe should be stacked on a reasonably flat surface , free from sharp objects , stones or projections likely to deform or damage them.

Contact with aggressive chemical products like liquid hydrocarbons should be avoided.

End cap shall be used and pipe shall be packed with rough rope or plastic belt.

Bundles

Pipe bundles should not be stacked unless the supporting frames are equally spaced to transfer safely the load from bundles to bundle through the corresponding frame and to avoid distortion of the pipe and facilitate safe lifting of bundles.

Each pipe bundles should be supported with 6 supporting frame (figure 1)

Pipe ends which are out of supporting frame should not exceed 50 cm.



Figure 1

Table 6. bundling of PE pipe

Size	No of pipe	No of row
110	14	4
125	11	3
160	8	3
200	5	3
225	5	3

Coil

Minimum inner diameter of coils:

For pipe with $DN \leq 63 = 23 \times OD$

For pipe with $DN > 63 = 20 \times OD$

12. Documentation:

The technical bid shall include the following

- 1) original catalogue showing materials , dimensions and etc
- 2) material specification for PE 80 and PE 100 issued by granules manufacturer
- 3) type test certificate that required by this standard which has been issued by a approved certification body include the following :
 - a) hydrostatic strength (20⁰C , 100 h)
 - b) squeeze – off followed by hydrostatic strength (80⁰C, 1000h)
 - c) elongation at break
 - d) resistance to slow crack growth for $e \leq 5\text{mm}$ (cone test)
 - e) resistance to slow crack growth fore $e > 5\text{mm}$ (notch test)
 - f) resistance to rapid crack propagation
 - g) resistance to short time hydraulic pressure (quick burst test)
 - h) conventional density
 - i) oxidation induction time
 - j) melt mass – flow rate
 - k) longitudinal reversion
 - l) carbon black content
 - m) carbon black dispersion
- 4) packing specification

13. Annex A

13.1. Normative

Pipes with peelable layer

13.1.1 General

This annex specifies the geometrical , mechanical and physical properties of those polyethylene (PE) pipes having an external peelable , skin or layer , thermoplastics layer on the outside of the pipe ("coated pipe"), intended to be used for the supply of gaseous fuels . Marking requirements are also given.

The PE- material used for the production of the base pipe shall be in accordance with table 3

The external skin shall be manufactured from a thermoplastic material. When attached, the skin shall not affect the ability of the PE pipe to meet the performance requirements of this standard specification.

13.1.2. Characteristics

13.1.2.1 Geometrical characteristics

This geometrical characteristics of the pipe, with the coating removed , shall be in accordance with clause 6.

13.1.2.2. Mechanical characteristics

The coating shall not have a detrimental effect on the pipe or vice versa. The mechanical characteristics of the pipe, with the coating removed shall be in accordance with table 3, and attachment of the coating shall not affect the ability of the pipe to conform with those requirements. table 3

When the pipe is tested with the coating attached , conformity with table 3 before and after weathering shall be assessed . The conditions selected shall ensure that pipe is subjected to the specified test stresses .

13.1.2.3. Physical characteristics

The physical characteristics of the pipe , with the coating removed , shall be in accordance with table 3. The coating shall not have a detrimental effect on the pipe or vice versa .

13.2. Marking

Marking shall be applied to the coating and shall be in accordance with clause 10.

In addition , the coating shall be provided with marking clearly distinguishing the pipe from non – coated pipe in service .

The coating shall also carry marking that warns that the coating must be removed prior to electro fusion and mechanical jointing .

13.3. Storage and installation

The coating shall be resistant to detachment during storage and installation . The coating shall be manually removable without damage being done to the pipe surface . Using simple tools in preparation for mechanical or electrofusion jointing . Exposed surfaces created immediately after coating removal shall be suitable for electrofusion .

13.4. Pipe peelability check

Every 4 hrs sample length of peelable pipe taken from each extrusion line shall be checked to ensure that the skin can successfully be peeled off pipes that are in manufacture the skin shall be peeled away completely from the core pipe for a minimum distance of 1 pipe diameter .

The pipe shall be deemed a "pass" if as a result of exerting reasonable force , the skin peels away from the core pipe in one piece without breaking , to leave a clean surface on the outside of the core pipe.

Peeling the skin from the core pipe shall be done by hand in all cases.

Should the pipe fail to meet the pass criteria, then those pipes manufactured subsequent to the last pass result shall be quarantined for further inspection.

The skin thickness along with the wall thickness and outside diameter of the core pipe shall also be measured. The skin thickness shall be in accordance with table 1 of Annex A , the core pipe wall thickness and outside diameter shall be in accordance with table 1 of this standard.

13.5. Color

External skin shall be black with 4 yellow axial stripes

Table 1 – peelable pipes: skin requirements

Dimensions in millimeters			
Nominal outside diameter ,dn	Minimum skin thickness	Strip	
		Width	Number
63	0.6	6±2	4
75	0.6	6±2	4
90	0.6	6±2	4
110	0.6	10±3	4
125	0.6	10±3	4
160	0.6	15±5	4
180	0.6	15±5	4
200	0.6	15±5	4
225	0.6	15±5	4

ANNEX B (Normative) – Data Sheet for Polyethylene Pipe

P.O. NO / Contract No.	
Manufacture's name and address	
Product	
Product designation	
Granule manufacturer & designation	

Raw Material

Item	Property	Unit	Test method	Requirement	Manufacturer's remark
1	Density	g/cm ³	ISO 1183	0.945	
2	Oxidation induction time	Min	ISO 11357-6	> 25 (T=210 ^o C) > 50 (T=200 ^o C)	
3	Melt mass flow rate (MFR)	g/10 min	ISO 1133	0.2 ≤ MFR ≤ 0.7	
4	Carbon black content	%	ISO 6964	2 to 2.5	
5	Carbon black dispersion		18553	Grade ≤ 3	
6	Designation			PE 80 / PE 100	

Finished product

Item	Property	Unit	Test method	Requirement	Manufacturer's remark
1	Elongation at break	%	En ISO 6259	≥ 400	
2	Straight pipe length	m		12	
3	Coiled pipe length	m		100	
4	SDR	-		11(PE 80 , PE100) 13.6 (PE100)	
5	Appearance	-		Black with 4 yellow stripes	
6	Hydrostatic test	-		According to IGS-M-PL-014-1(2)	

Notes:

- 1- This data sheet shall be filled, signed, and stamped by manufacturer / supplier.
- 2- Any deviation from this standard specification shall clearly be specified by manufacturer / supplier.
- 3- Any change in raw material shall be requified
- 4- Requirements for material , manufacturing , testing , inspection , packing , etc are in accordance with EN 1555: 2008 & IGS-M-PL-014-1(2)
- 5- Processed PE material (recycled or reused) are not allowed