

# Webinar III June 2023



# SAPPMA

southern african plastic pipe manufacturers association



15-06-2023

## Repeatability vs. Reproducibility: Who would use repeatability and/or reproducibility?

Both repeatability and reproducibility are essential in nearly all areas of science, including chemistry, computer science, data science, and engineering. A line operator in a manufacturing facility may rely more on repeatability, whereas a chemist developing a new chemical reaction would strive to achieve reproducibility of their experimental method and rely on repeatability data to determine its accuracy.



### Accuracy and repeatability



Accurate = Precise = Valid  
Repeatable = Consistent = Reliable  
Accurate + Repeatable = Trust





# To Do or Not to Do

ISBN 978-0-626-31526-9

**SANS 10270:2015**  
Edition 1.3

## Choosing Between Repeatability and Reproducibility: Real World Scenarios

Let's say a quality inspector is measuring the weight of different sized bolts to ensure they are within the acceptable range before sending them through to the next step in the manufacturing process. To determine the reliability of the scale, the head engineer wants the operator to weigh each bolt multiple times and record their results. Essentially, the operator is performing a repeatability test. The engineer notices that the scale appears to be having a significant variation in bolts that weigh more than 50 grams. The conclusion is that a different scale capable of producing repeatable measurements on the same bolts over 50 grams needs to be installed at the quality inspector's station. This simple repeatability test allowed the engineer to catch a potential area of inaccuracy in the manufacturing process and potentially avoid costly quality and functional issues in the end product.

Reproducibility is a major goal of research teams and collaborations in the field of chemistry. Let's say a team of chemists has produced a chemical reaction that can create a nickel complex that absorbs near-infrared light. The team has designated one of its members to perform the test multiple times and record their data. They have come to the conclusion that their experiment is repeatable. The team is in collaboration with another team working on the same goal of producing safer materials for solar panels. They send their method to the other team and ask them to perform the experiment multiple times and record their data. Several of the other teams' members reproduce the same results as the original team. The experiment can now be deemed reproducible, and the team can move on to improving the process so it can be scaled for production.

## SOUTH AFRICAN NATIONAL STANDARD

### Welding of thermoplastics — Approval of welding procedures and welds

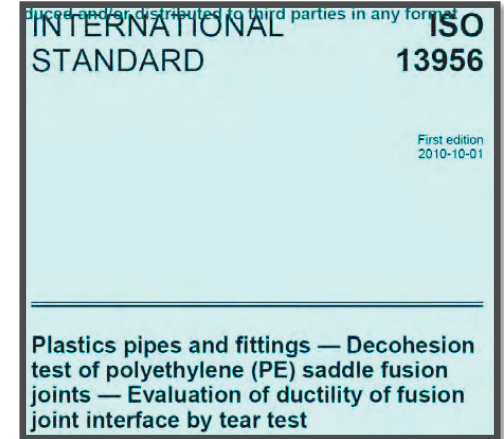
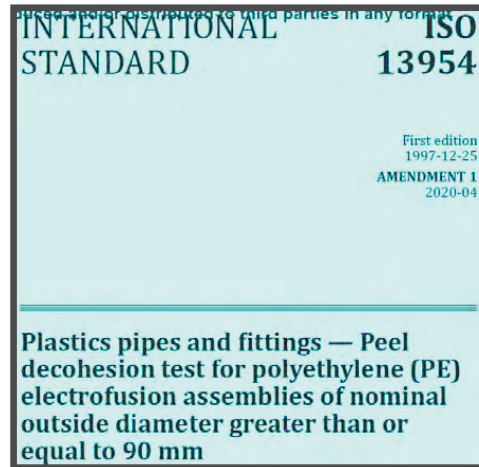
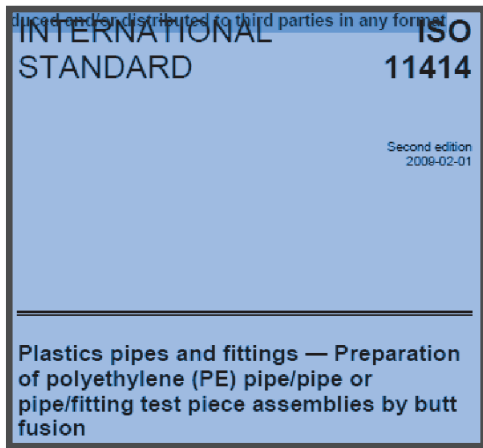
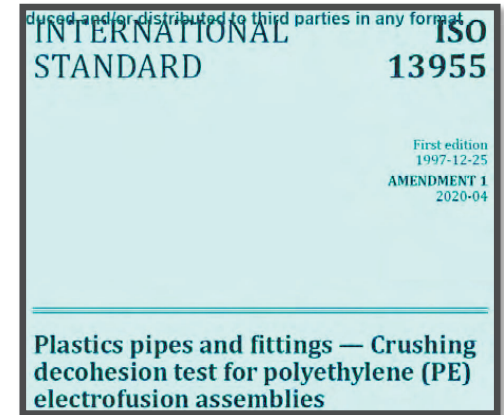
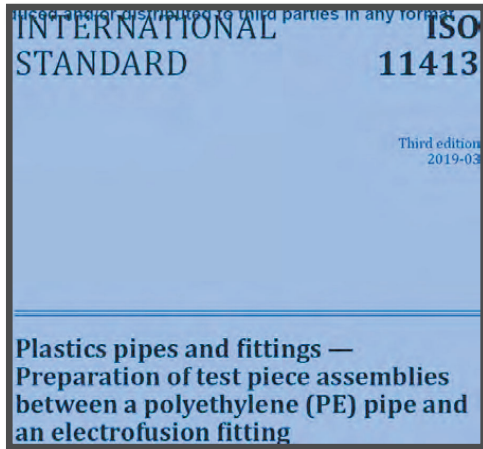
## Summary

Depending on what industry you work in, you may need to use repeatability and/or reproducibility tests. If you are simply trying to determine the accuracy or consistency of a measuring tool, repeatability tests are likely all you need. However, if you are developing new processes and/or products, both repeatability and reproducibility are essential in the process of moving your ideas from planning to experimentation to production.



15-06-2023

# To Do or Not to Do- Normative Standards in ISO 4427



15-06-2023





## “Quality concepts in HDPE fusion welding and extrusion welding techniques .”



Longer lifetimes, leak-free or reduced maintenance are the expected outcomes from using polyethylene pipes. To achieve this goal, there are simple proven techniques for joining pipes during the construction phase. The technique of fusion welding for the pressure pipes and extrusion welding for structured wall pipes has been shown to consistently deliver quality pipe joints under a broad range of installation conditions.

Saravanan Babu, Plastic Pipe Testing & QMS Specialist from Plasco Limited, Dar Es Salaam, Tanzania, will share his knowledge and experience about the HDPE Pipe fusion and Extrusion welding techniques. QA/QC concepts around those techniques shall also be discussed in the session.

We invite you to join us for a SAPPMA Webinar to learn from his wealth of understanding of the subject matter.

# SAPPMA

southern african plastic pipe manufacturers association



# Presenter

SAPPMA Webinar III 2023

15 June 2023



Saravanan Babu



15-06-2023





# Theories about Thermoplastic Welding

Welding is an interaction at the interface of surfaces of interatomic and intermolecular forces.

- Adhesion theory: ratio of surface energies of the two materials where the maximum adhesion is obtained in the case of identical material where the specific contact surface energy is zero.
- Viscoelastic contact theory: molecular forces such as Van Der Waals act on the surfaces which deformed under welding pressure, forming a boundary surface as a function of time.
- Diffusion theory: diffusion of chains or chain segments across the weld interface, provided that the polymers are mutually soluble, and the molecules have sufficient mobility achievable by exceeding a certain minimum temperature threshold.
- Flow process theory: mechanical displacement of chains in the flow field generated by the welding pressure and temperature, forcing mixing to occur as a result of both thermal and mechanical displacement processes.



# HDPE Pipe Welding Techniques

High-density polyethylene (HDPE) pipes are widely used in oil and water systems due to their ease of installation, long service life, good corrosion resistance, environmental protection ability, and excellent mechanical properties.

In order to ensure the water-tightness and integrity of the pipeline, HDPE pipes are usually welded with various techniques.

The main welding methods for HDPE pipes for pressure transmission applications are butt fusion welding and electrofusion welding.

Extrusion welding is a technique followed to weld structured wall HDPE pipes which are manufactured in accordance with ISO 21138 standards.





## Significance of a Good Pipe joint

- Proper Engineering design of a pipeline involves the consideration of the type and effectiveness of the techniques used to join the pipeline components as well as the durability of the resulting joints.



## Factors influencing the Weld Quality

**Cleanliness:** In the field of welding, no matter what the material, cleanliness matters and should be emphasized throughout the process.

- Machines shall be clean
- Pipe surface, welding materials shall be clean
- Welding area should be protected at the construction site

All such parameters shall be designed to prevent contaminants getting into the weld which might reduce the lifetime of the asset being installed.





# Factors influencing the Weld Quality

**Heat energy:** To make a satisfactory weld the pipe/weld material must be heated such that all the material at the end of the pipes to be joined has achieved the target temperature for the operation and holds this temperature until the pipe ends pressed together.

Too much heat may degrade the material, too little heat affects the weld strength, so the key is to achieve the target temperature range set out in the specifications.

**Pressure:** The pressure, sometimes referred to as the interfacial pressure experienced by the pipe ends when they are butted against each other matters.

Pressure is used to ensure the molten pipe ends are fully squeezed together to form an intimate connection so the minimum level matters.

Too much pressure can squeeze all the molten material out of the welded area. So, a target range matters.



## Factors influencing the Weld Quality

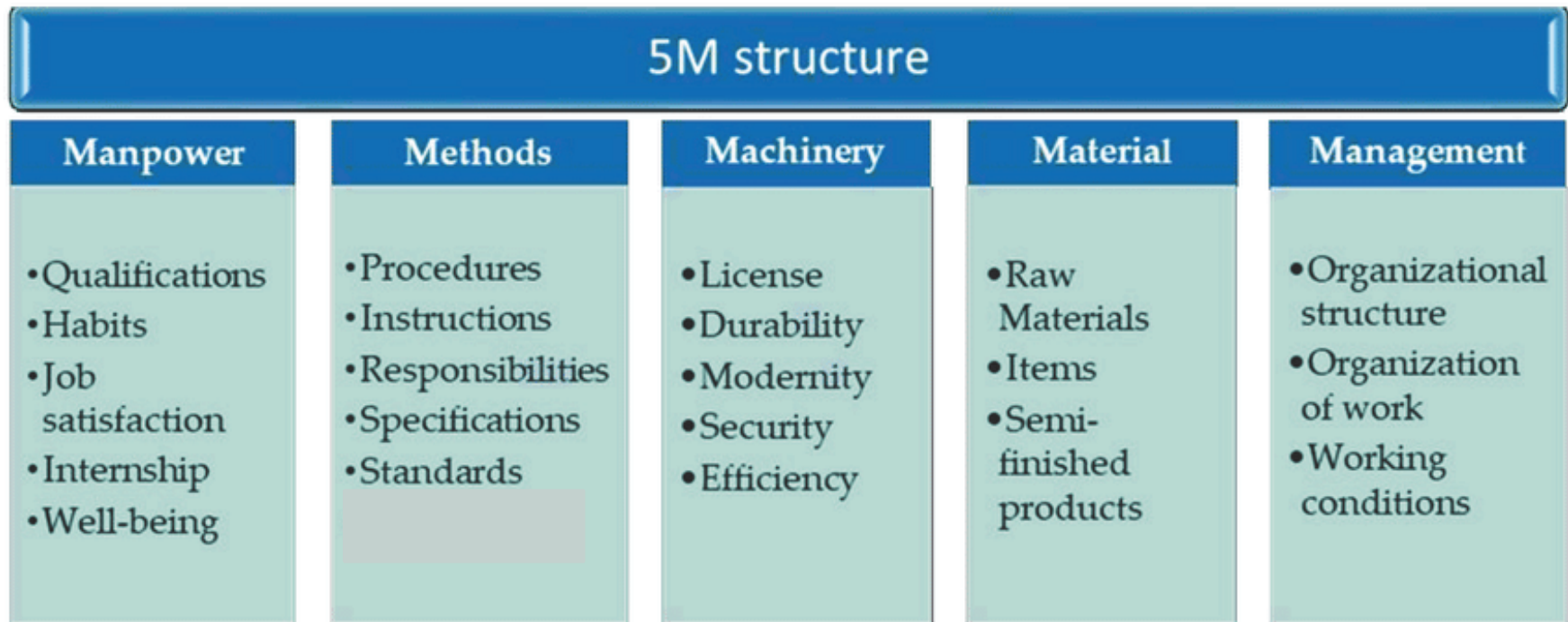
**Time:** Each of the cycle times has a design intent behind it, whether this is ensuring adequate time for heat to soak into the pipe ends, ensuring they don't cool down too quickly when heater plates are removed and so forth.

But what also matters is allowing the joint to cool properly in the clamps when a weld has been made, the material has to reform its crystalline structure to allow it to be handled without damage.





# The 5M's affecting the Weld Quality



# The 5M's affecting the Weld Quality - Manpower

The key to the success of any welding process is based on the skills of the welder and the dedication to correct surface preparation and follow correct weld procedures.

All welding operators should be qualified and regularly recertified with a qualification test.

DVS 2212, SANS 10269





# The 5M's affecting the Weld Quality - Manpower

## WELDER IDENTIFICATION AND TRACEABILITY

S/N	NAMES		WELD IDENTIFICATION NO.
1	MIRAJI	ALLY	PF - 106
2	ALLY	SHABANI	PF - 172
3	MARCELIUS	NCHIMBI	PF - 174
4	ABDUL	MOHAMED	PF - 177
5	RUDIEL	LEMA	PF - 236



15-06-2023

# The 5M's affecting the Weld Quality – Method

The SANS 10268 (part 1 to 10)/DVS 2207 (part 1 to 10) is a series of standards applies to jointing thermoplastic materials.

The first part of the standard discusses heated tool welding of PE-HD sheets, pipes, and pipeline components.

In addition, this section covers heated plate butt welding, socket welding, and electro-fusion welding of pipes.

In these standards, instructions for how to prepare components for welding, how to carry out welding itself, and how to test the welding are laid out and identify defects along with allowable tolerances.

SANS 10268-1	2009	1.03 Welding of thermoplastics - Welding processes Part 1: Heated-tool welding
SANS 10268-2	2004	1.01 Welding of thermoplastics - Welding processes Part 2: Electrofusion welding
SANS 10268-3	2005	1.01 Welding of thermoplastics - Welding processes Part 3: Hot-gas welding
SANS 10268-4	2004	1.01 Welding of thermoplastics - Welding processes Part 4: Hot-gas extrusion welding
SANS 10268-5	2004	1.01 Welding of thermoplastics - Welding processes Part 5: Solvent welding
SANS 10268-6	2003	1.00 Welding of thermoplastics - Welding processes Part 6: Ultrasonic welding, staking and insertion
SANS 10268-10	2009	1.03 Welding of thermoplastics - Welding processes Part 10: Weld defects

## The 5M's affecting the Weld Quality – Machinery

- The ISO 12176-1 and 12176-2 standards sets the pre-requisites of the equipment to qualify for the HDPE Butt fusion and Electrofusion welding activities.
- DVS 2207-4 elaborates extrusion welding process, parameters and requirements on the extrusion welding equipment and devices.





## The 5M's affecting the Weld Quality – Material

Choice of Raw materials used for pipe/fitting manufacture has a major impact in the weld quality.

Requirements for raw materials to be used in the HDPE Pipe manufacture is guided in the relevant product standards. Ex. 4427-1, 4437-1 etc.

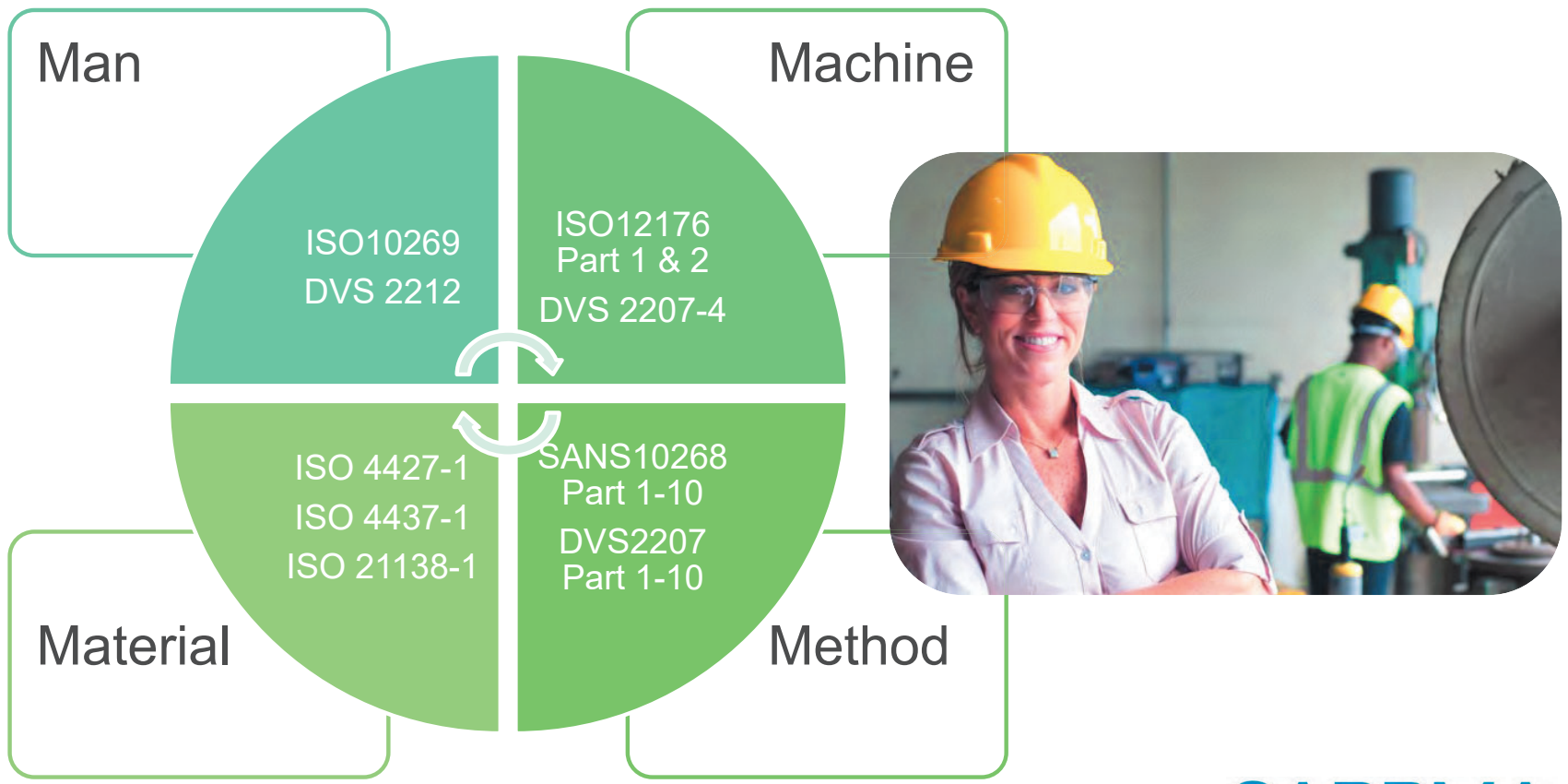
PE pipes are designed for a long lifetime (in excess of 100 years) in the underground infrastructure. Indeed, installing the pipe in the ground is the most expensive part of operation (typically 85 – 90% of the project costs) so the last thing a gas or water engineer wants to do is replace the pipes within their working lifetime.

This “Peace of Mind” demands consistent materials and products which can only be achieved if the carbon black or pigment and other essential additives are correctly dispersed in the polymer matrix.



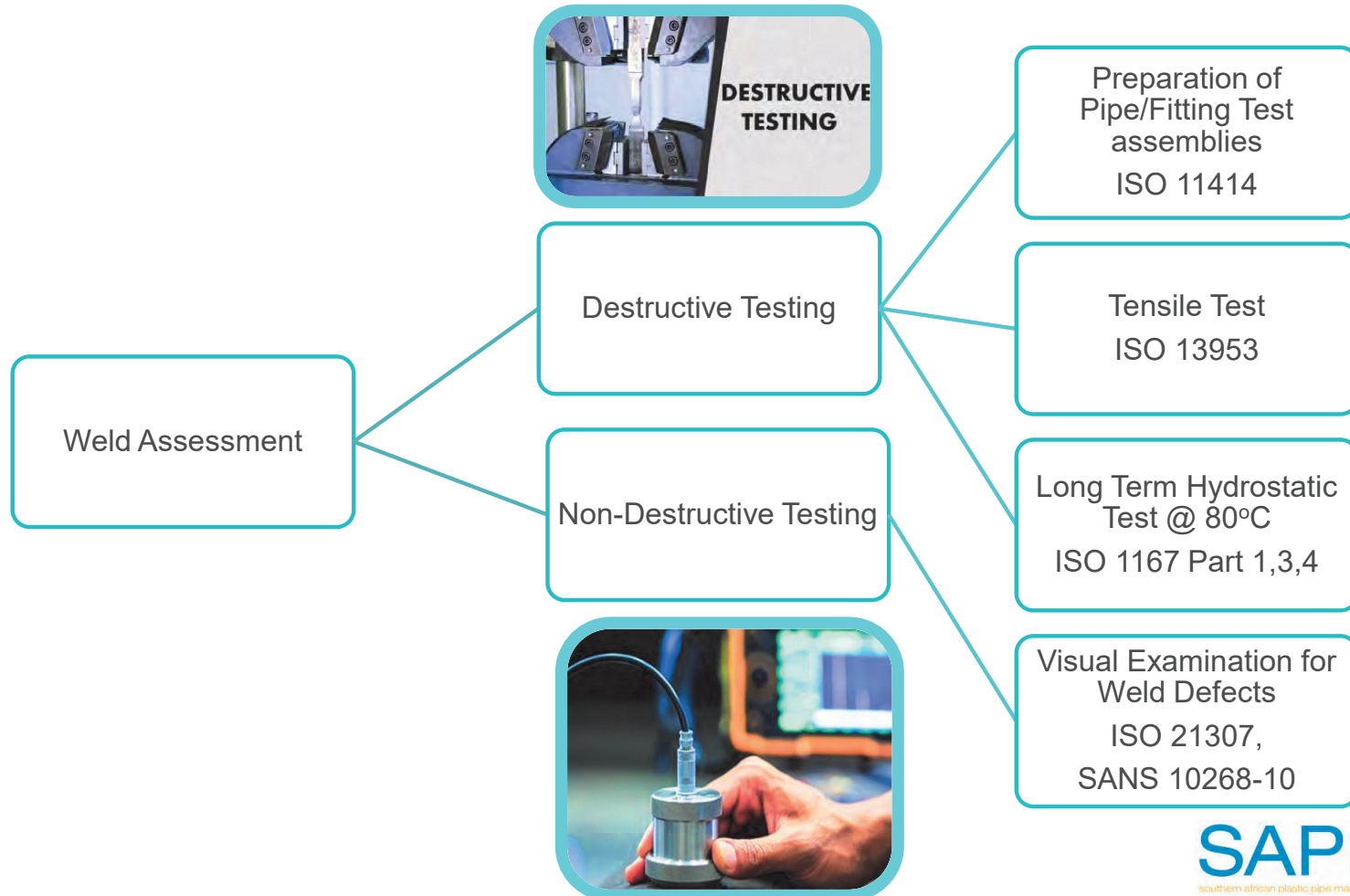
15-06-2023

# The 5M's affecting the Weld Quality – Management



15-06-2023

# Assessment of Weld Quality – Butt Fusion Welds





# Assessment of Weld Quality – Electro Fusion Welds



Weld Assessment

Preparation of Pipe/Fitting  
Test assemblies  
ISO 11413

Decohesion Test for  
assemblies  $\geq 90$ mm OD  
ISO 13954

Crushing decohesion test  
for polyethylene (PE)  
electrofusion assemblies  
ISO 13955



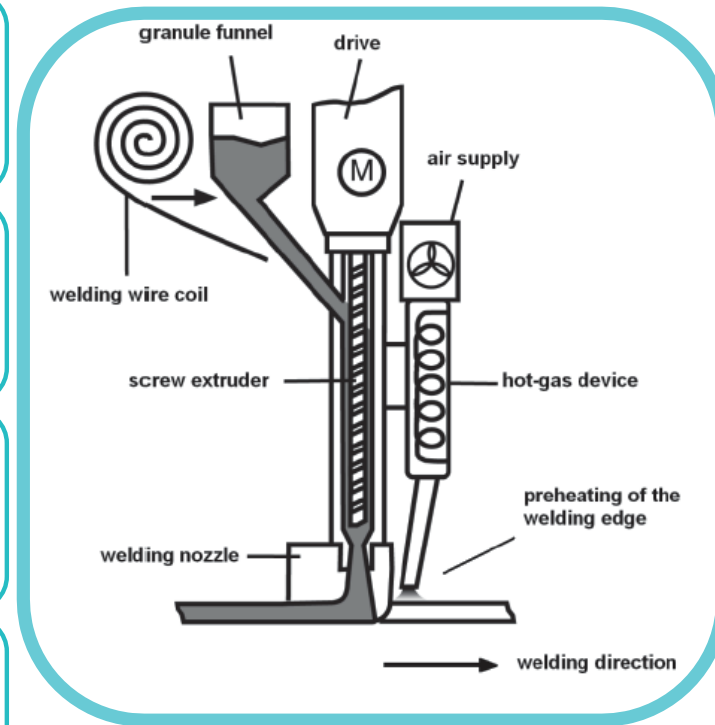
# Extrusion Welding

Extrusion welding is a manual or semi-automatic welding process which is performed with a welding filler (either in wire or granule form) which is melted/plastified in a system (Extruder)

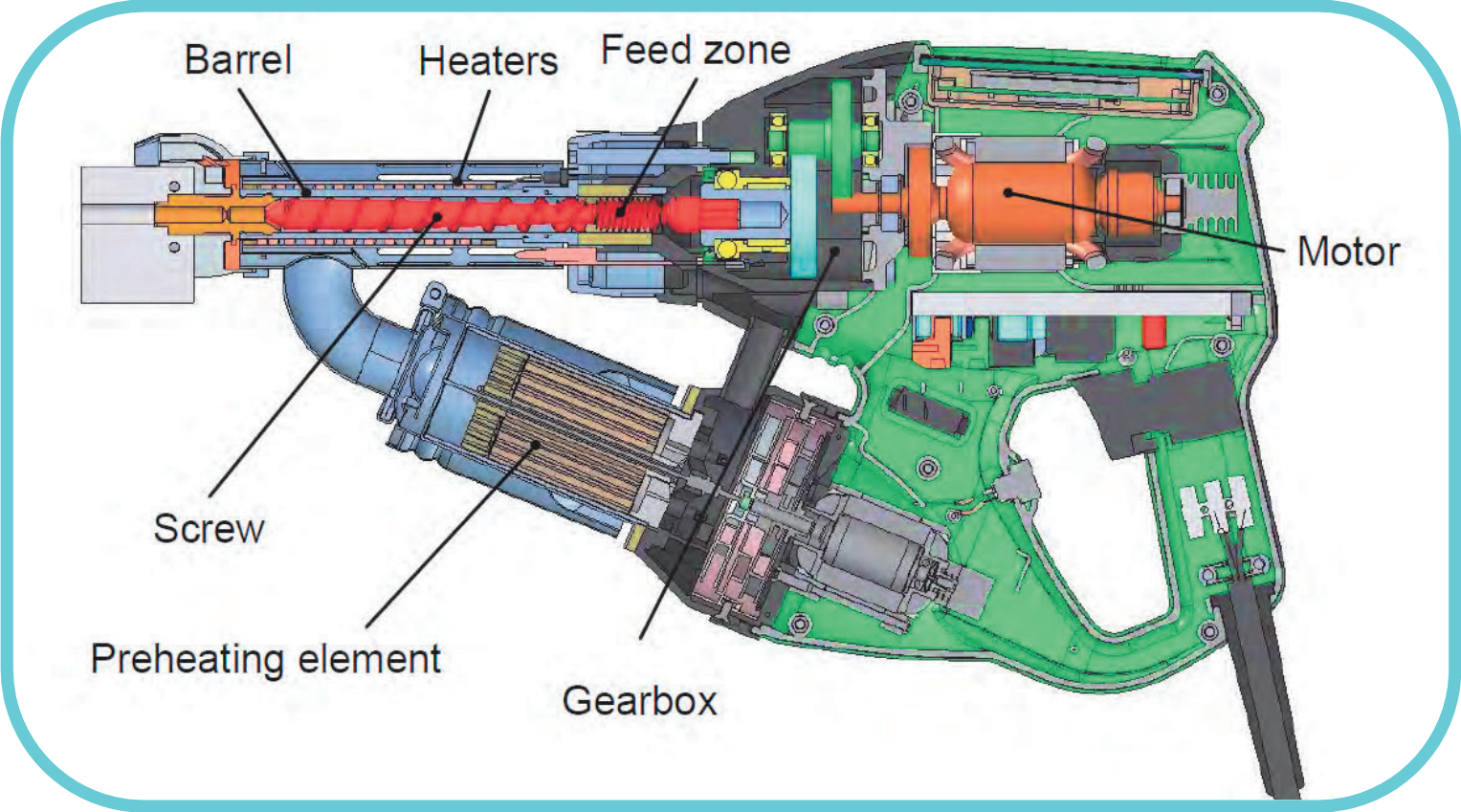
A welding shoe shaped according to the weld geometry is used to press the plastified/molten filler into the groove of the base material using hot air

The output capacity of the welding machines determines the max weld dimensions and influences the welding speed

The joining pressure is generated by the emerging material from the weld gun and the counterforce of the welder.



# Extrusion Welding Gun





# Extrusion Welding Process

## Weld Preparation

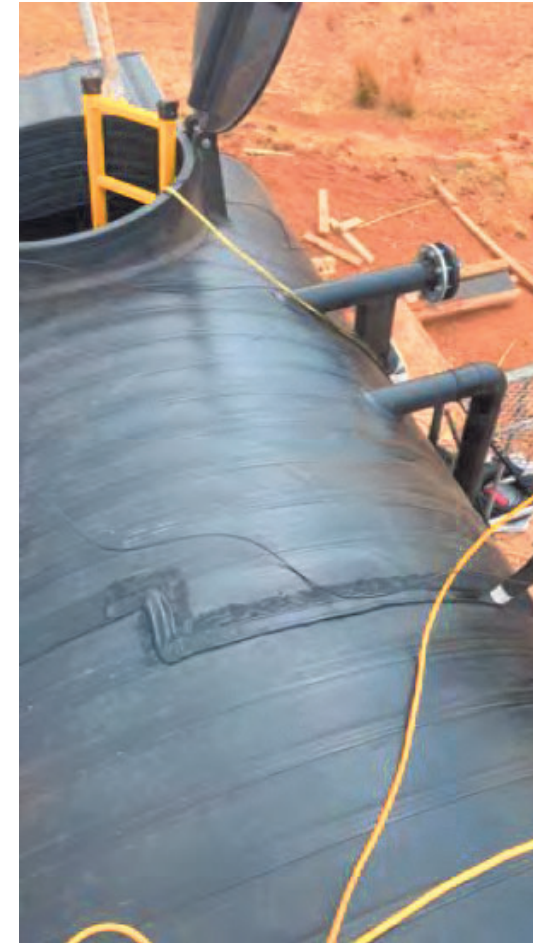
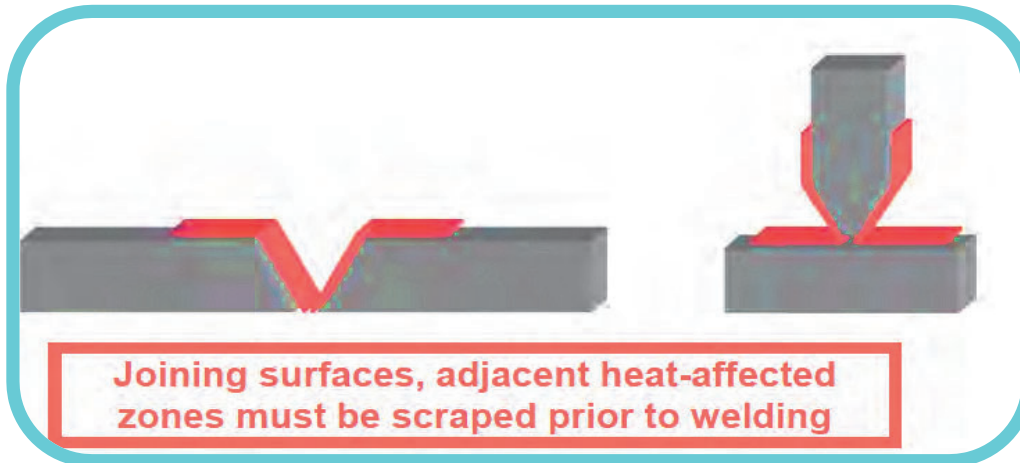
The welding surfaces must be:

- Aligned, held and steady in position

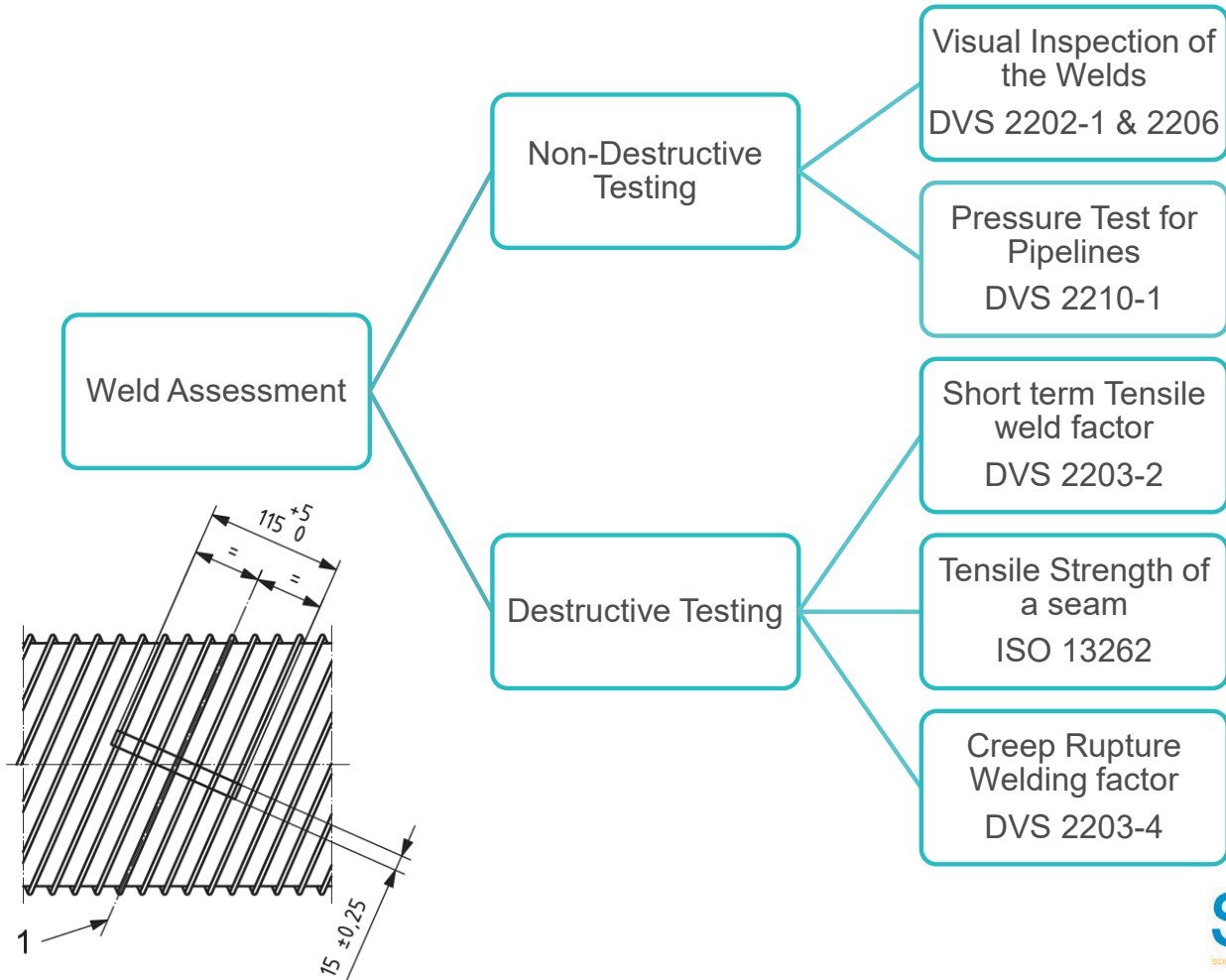
dry, clean, oil- and grease-free

free of loose shavings and

free of notches



# Assessment of Weld Quality – Extrusion Welds



# Pressure/Leak Test for Extrusion Welds



IFPA



15-06-2023



# Weld Factor determination for Extrusion Welds

The tensile welding factor  $f_z = F_V/F_B$  is determined from the

- mean values of the fracture forces of the welded test specimens ( $F_V$ ) and the
- Fracture forces of the reference test specimens ( $F_B$ ).

If the specimens are stretched before fracture, the force at yield stress shall be taken as the reference value.

Table 4 — Minimum requirements for the tensile welding factor  $f_z$

1	2	3	4	5	6
Welding process	Tensile welding factor $f_z$				
	PE-HD	PP	PVC-C	PVC-HI PVC-U	PVDF
Heated-tool welding	0,9	0,9	0,8	0,9	0,9
Extrusion welding	0,8	0,8	–	–	–
Hot-gas welding	0,8	0,8	0,7	0,8	0,8
Electrofusion welding	0,9	0,9	–	–	–
Solvent welding	–	–	0,8	0,9	0,9

# Quality Assurance checklist in HDPE Welding

---

Document control and distribution according to ISO9001

---

List of Welders and team showing qualifications, responsibilities, training, experience;

---

Welding procedures/SoP's;

---

Signed off weld records

---

Inspection and test Plan (tailored to suit the specification);

---

Any other items required by the specification



# QA samples in HDPE Welding



S/N	NAMES		PF NUMBER	PUNCH NUMBER	VISUAL	BUTT WELD ASSESMENT	EXTRUSION WELD ASSESMENT	
						BURST TEST	VISUAL	TENSILE TEST
1	MIRAJI	ALLY	PF - 106	106	GOOD	BURST AT MAX PRESSURE OF 65.74BARS (PASSED)		
2	ABDUL	MOHAMED	PF - 177	177	GOOD	BURST AT MAX PRESSURE OF 65.69 BARS (PASSED)		
3	ILDEFONS	MNIMBO	PF - 282	282	GOOD	BURST AT MAX PRESSURE OF 66.24 BARS (PASSED)	GOOD	PASS
4	IDDI	KASSIM	PF - 298	298	GOOD	BURST AT MAX PRESSURE OF 65.89 BARS (PASSED)	GOOD	PASS
5	JULIUS AMOS	MWINAMILA	PF - 308	308			GOOD	PASS
6	MOHAMED ALNURU	SAFARI	PF - 313	313	GOOD	BURST AT MAX PRESSURE OF 40.16 BARS (PASSED)	GOOD	PASS
7	JAMES	KASAWA	PF - 343	343	GOOD	BURST AT MAX PRESSURE OF 65.74 BARS (PASSED)	GOOD	PASS
8	LEMA	ISSA	PF 382 / 10 / 20	541	GOOD	BURST AT MAX PRESSURE OF 66.29 BARS (PASSED)	GOOD	PASS
9	NGOMELA	OMALI	PF - 362 / 02 / 20	362	GOOD	BURST AT MAX PRESSURE OF 31.08 BARS (PASSED)	GOOD	PASS
10	MFANYEJE	SALEHE	PF - 363	543	GOOD	BURST AT MAX PRESSURE OF 65.39BARS (PASSED)	GOOD	PASS



15-06-2023



# QA samples in HDPE Welding

PLASCO LIMITED		WELDING RECORD AND TABLE				Form: 07.03.02 Rev 2	Sheet No										
Report for heated plate welding of tubular components																	
Client	MKULAZI	Weather Conditions (WC)	1 = sunny 2 = dry	Protective Measures (PM)	1 = none 2 = screen 3 = tent 4 = heating	In the case of multiple designations, follow the figures as above* (e.g. 34 = rain and wind)											
Project	REPAIR OF THE PIPE		3 = rain or snowfall														
Order No			4 = wind														
Material	PE 100		5 = dust	Welding machine													
Name of Team Leader	DANIEL MSHANA	Welding machine		Make	tuft 315	Location	MKULAZI FARM										
Name and signature of welder No. 1	ILDEFONS MNIWUBO	Type			TM 315												
Name and signature of welder No. 2	ALLY NAWA	Machine No			M152AR65014												
		Year of manufacture			2016												
Ser No	Weld No	Date (Day/Mth)	Pipe Size (mm)	Heating Element Temp * C **	Drugging Force p **	Join Pressure(P) Under Cooling	Adjusted values Soak (P)	Bead Lip	Soak Time	Dwell Time	Shifting	Cooling Time Under Join Pressure(P)	Code No WC	Code No PM	Starting Time	Finish Time	Remarks
1	01	05-11	315	220	4	48	0	48	12	15	15	16	2	1	12:20	12:59	
2	02	05-11	315	220	4	48	0	48	12	15	15	16	2	1	12:59	13:44	
3	03	05-11	315	220	4	48	0	48	12	15	15	16	2	1	14:20	15:11	
4	04	05-11	315	220	4	48	0	48	12	15	15	16	2	1	16:10	16:47	
5	05	05-11	315	220	4	48	0	48	12	15	15	16	2	1	16:55	17:35	
6	06	05-11	315	220	4	48	0	48	12	15	15	16	2	1	18:05	19:48	



WEHOLITE WELDING INSPECTION AND TEST PLAN

THIS DOCUMENT MUST BE COMPLETED IN FULL ON BOTH SIDES

Plasco Order No	Joint Number*	Date	Gap 15min	Gap >15min	Standard Root + Cap	Plated Fillet	Box Section	Vertical Dimension	Horizontal Dimension	Temperature	Visual Insp. Sign	Comments
	01		✓		ROOT			350	350	22°C	OK	✓
	02		✓		ROOT			350	350	23°C	OK	✓
	03		✓		ROOT			350	350	24°C	OK	✓
	04		✓		ROOT			350	350	26°C	OK	✓
	05		✓		ROOT			350	350	26°C	OK	✓
	06		✓		ROOT			350	350	27°C	OK	✓
	07		✓		ROOT			350	350	28°C	OK	✓
	08		✓		ROOT			350	350	28°C	OK	✓
	09		✓		ROOT			350	350	28°C	OK	✓
	10		✓		ROOT			350	350	27°C	OK	✓
	11		✓		ROOT			350	350	27°C	OK	✓
	12		✓		ROOT			350	350	28°C	OK	✓
	13		✓		ROOT			350	350	28°C	OK	✓
	14		✓		ROOT			350	350	28°C	OK	✓



# QA samples in HDPE Welding

PLASCO LIMITED  
Plot No.112, Mbozi Road, Chongamba,  
P.O. Box 19956, Dar es Salaam, Tanzania  
Tel: +255 (0)22-8199 820/821/821  
Email: plascoaltd@plasco.co.tz  
Web: www.plasco.co.tz

**PLASCO**  
WE STAND FOR QUALITY


Form 07.02.04 Rev 2

### FIELD SERVICES JOB ORDER COMPLETION FORM


CUSTOMER NAME: RWANDA CUSTOMER PURCHASE ORDER NUMBER: CG 000106000  
SITE/LOCATION: R. D. BOX 480 KISALI RWANDA ORDER DATE: 31-MAY-2022

JOB EXECUTED: BUTT WELDING  ELECTROFUSION WELDING  EXTRUSION WELDING

BRIEF JOB DESCRIPTION:  
Welding of Waterline pipes DN 1400 SN 8 for SAKIYA Dam in RWANDA KISALI. Pipes welded in 9 rows and 784 meters.

COMPLETED ON: 30/10/2022 TEAM LEADER SIGNATURE: 

CUSTOMER COMMENTS:  
JOB COMPLETED SATISFACTORILY: YES  NO

CUSTOMER NAME: Jean Claude NBAMUKONDA CUSTOMER SIGNATURE:   
DATE: 30/10/2022



PLASCO LIMITED  
Plot No.112, Mbozi Road, Chongamba,  
P.O. Box 19956, Dar es Salaam, Tanzania  
Tel: +255 (0)22-8199 820/821/821  
Email: plascoaltd@plasco.co.tz  
Web: www.plasco.co.tz

**PLASCO**  
WE STAND FOR QUALITY

Form 07.02.04 Rev 2

### FIELD SERVICES JOB ORDER COMPLETION FORM

CUSTOMER NAME: MASIRO ESTATES (T) LTD CUSTOMER PURCHASE ORDER NUMBER: MS147481  
SITE/LOCATION: IRINGA TANZANIA ORDER DATE: 28-Nov-2022

JOB EXECUTED: BUTT WELDING  ELECTROFUSION WELDING  EXTRUSION WELDING

BRIEF JOB DESCRIPTION:  
EXTRUSION WELDING OF 350mm SN-4 ACCORDING TO CUSTOMER REQUIREMENTS.

COMPLETED ON: 7/12/2022 TEAM LEADER SIGNATURE: 

CUSTOMER COMMENTS:  
JOB COMPLETED SATISFACTORILY: YES  NO   
Very professional, fast and easy. Thanks!

CUSTOMER NAME: Masiro Estates LTD. CUSTOMER SIGNATURE:   
DATE: 07/12/22

MASIRO ESTATES (T) LTD.  
P.O. Box 1434 - IRINGA  
TEL: 0783 207 334



*Presenter*

**SAPPMA Webinar III 2023**



15 June 2023



**Saravanan Babu**



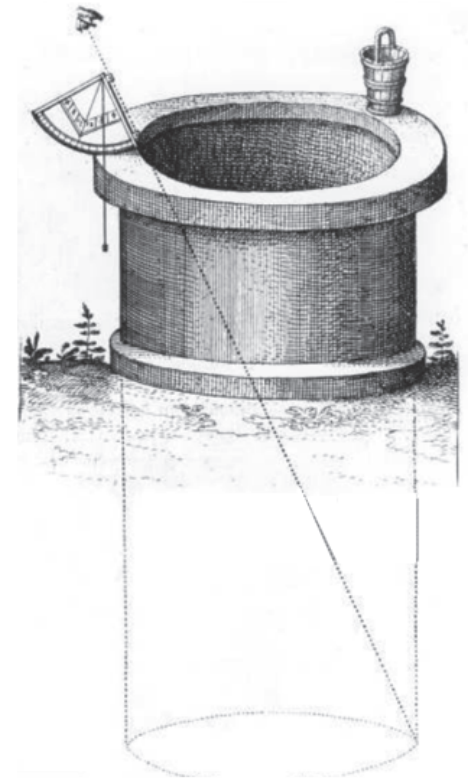
15-06-2023



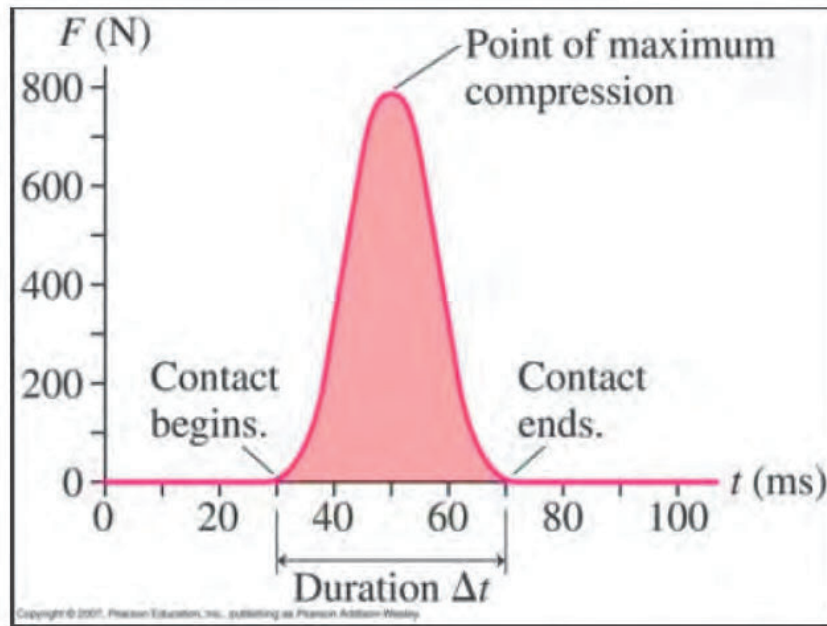
# Why do we determine weld factors?

Welder, process, equipment, components at a specific location may not result in performing welds

- The components and component supplier/product/s may be non-conforming and can not be welded
- Initial weld factor confirms functionality of the preliminary welding procedure
- ongoing weld factor/s (min 1% of welds) confirms reproducibility



## Effect of Force and time



Does It  
**Really**  
Matter?



# We evaluate the weld results

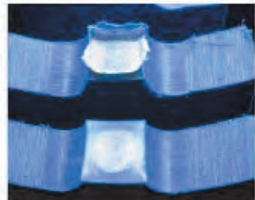
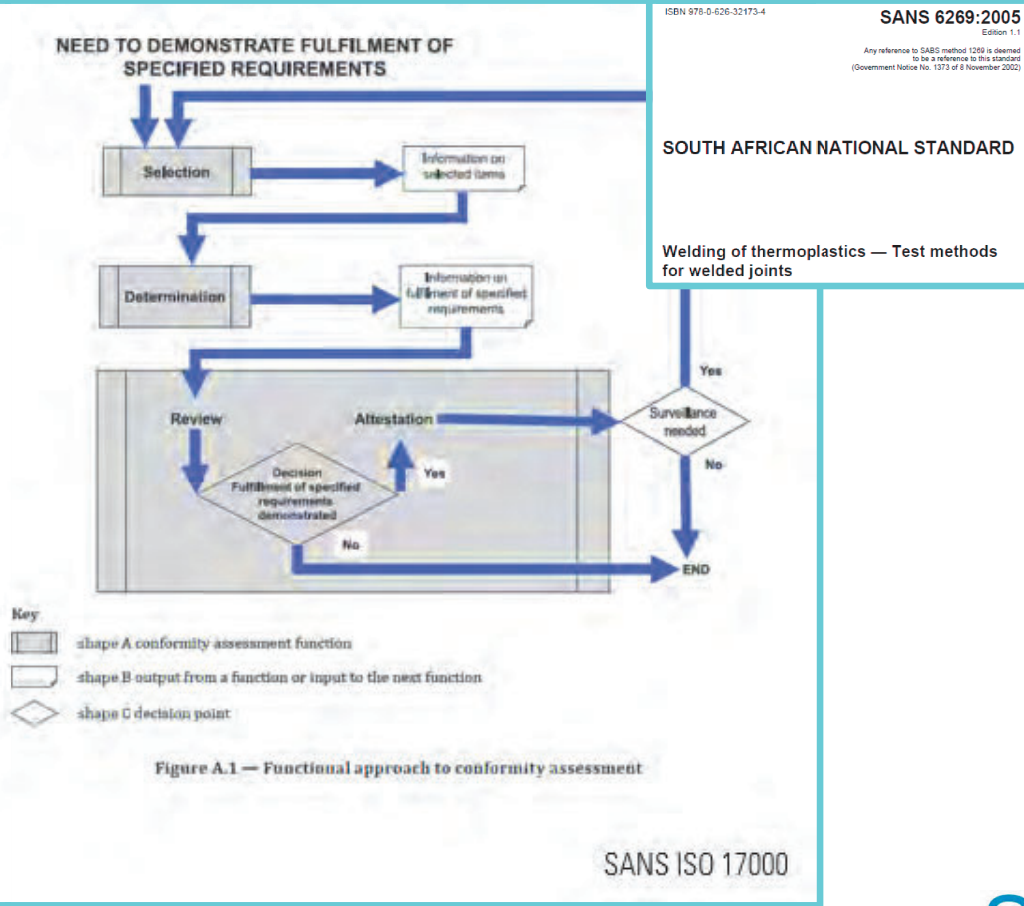


Figure 2: showing fully ductile failure mode of tensile weld specimen

Figure 3: showing "mixed" and brittle failure modes of tensile specimen

## NEED TO DEMONSTRATE FULFILMENT OF SPECIFIED REQUIREMENTS



ISBN 978-0-626-31526-9

**SANS 10270:2015**  
Edition 1.3

**SOUTH AFRICAN NATIONAL STANDARD**

Welding of thermoplastics — Approval of welding procedures and welds

ISBN 978-0-626-34357-6

**SANS 21307:2011**  
Edition 1

**ISO 21307:2009**  
Edition 1

**SOUTH AFRICAN NATIONAL STANDARD**

Plastics pipes and fittings — Butt fusion jointing procedures for polyethylene (PE) pipes and fittings used in the construction of gas and water distribution systems

ISBN 978-0-626-34817-5

**SANS 10268-10:2009**  
Edition 1.3

**SOUTH AFRICAN NATIONAL STANDARD**

Welding of thermoplastics — Welding processes

Part 10: Weld defects



# Then we Attestate

## attestation



### noun

1. The act of attesting; a declaration, verbal or written, in support of a fact; evidence; testimony.
2. The administration of an oath, as to a military recruit. See attest, 4.
3. The act of attesting; testimony; witness; a solemn or official declaration, verbal or written, in support of a fact; evidence. The truth appears from the attestation of witnesses, or of the proper officer. The subscription of a name to a writing as a witness, is an attestation.
4. A thing that serves to bear witness, confirm or authenticate.
5. A confirmation or authentication.
6. The process, performed by accountants or auditors, of providing independent opinion on published financial and other business information of a business, public agency, or other organization.
7. An appearance in print or otherwise recorded on a permanent medium.
8. the action of bearing witness
9. the evidence by which something is attested



15-06-2023

We are Jointly Responsible

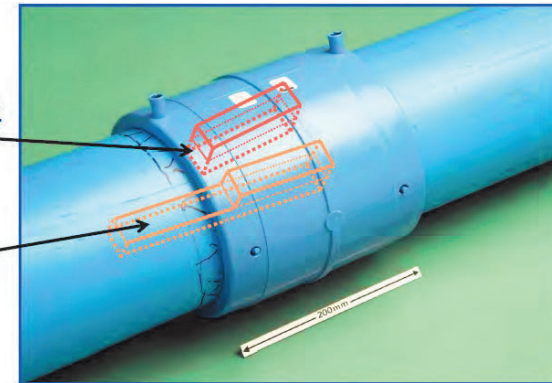
# SAPPMA

southern african plastic pipe manufacturers association



EN 12814 - 4  
sample

ISO 13954  
sample



**SAPPMA**  
southern african plastic pipe manufacturers association

## Questions and Answers



[ian@sappma.co.za](mailto:ian@sappma.co.za)  
[admin@sappma.co.za](mailto:admin@sappma.co.za)