FORM NO. RSSPMP1302 | REV. (1)

Document C

ROYAL SCIENTIFIC SOCIETY

MECHANICAL DESIGN AND TECHNOLOGY CENTER

Corrosion Engineering Division
P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276
Fax : (962)65344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

Designation No.:	3/05/1819	Our Ref. & Date:	(3)148/55/1/22467 Date: 09/2006
		Method of Sampling:	
		Date of Test:	

This study is based on verifying the effect of using HYDROFLOW Technology given in fig.(1), in reducing scaling and corrosion rate in JORDAN STEEL FACTORY (JSF).Seven random positions were selected in JSF cooling water piping network as shown in fig.(2) to install (14) corrosion and scale coupons as shown in figs.(3-10) for one year (4/1/2006 to 4/1/2007) .Seven Carbon Steel coupons (2 x 4 cm.) as well as bolts and nuts were fabricated from the same material of JSF piping network at MDTC/RSS mechanical workshop in order to use them as corrosion coupons (CC)to be connected in the selected positions given in fig.(2).Seven Scale coupons (SC) ,(2 x 4 cm.) of Super Stainless Steel Alloy (NAS 254N) as well as (S 64 , 304) supplied by NIPPON YAKIN KOGYO CO.,LTD/JAPAN were fabricated at MDTC/RSS mechanical workshop in order to use them as scale coupons to be connected in the selected postions given in fig.(2) using plastic bolts and nuts to eliminate the GALVANIC action that might occur between the material of the scale coupons and the material of the pipe.

Fig.(1) Hydroflow technology (photo to the left) connected to one of the pipes in a selected location of JORDAN STEEL FACTORY (photo to the right).

Consultant:Dr.Farqad F.M.Saeed F.F. Saeed Consultant: Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN &
TECHN... CENTRE

(1)

FORM NO. RSSPMP1302 | REV. (1)

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN AND TECHNOLOGY CENTER
Corrosion Engineering Division
P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276
Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

Designation No.: 3/05/1819	Our Ref. & Date:	(3)148/55/1/22467	Date 10/9/2006
	Method of Sampling:		
	Date of Test:		

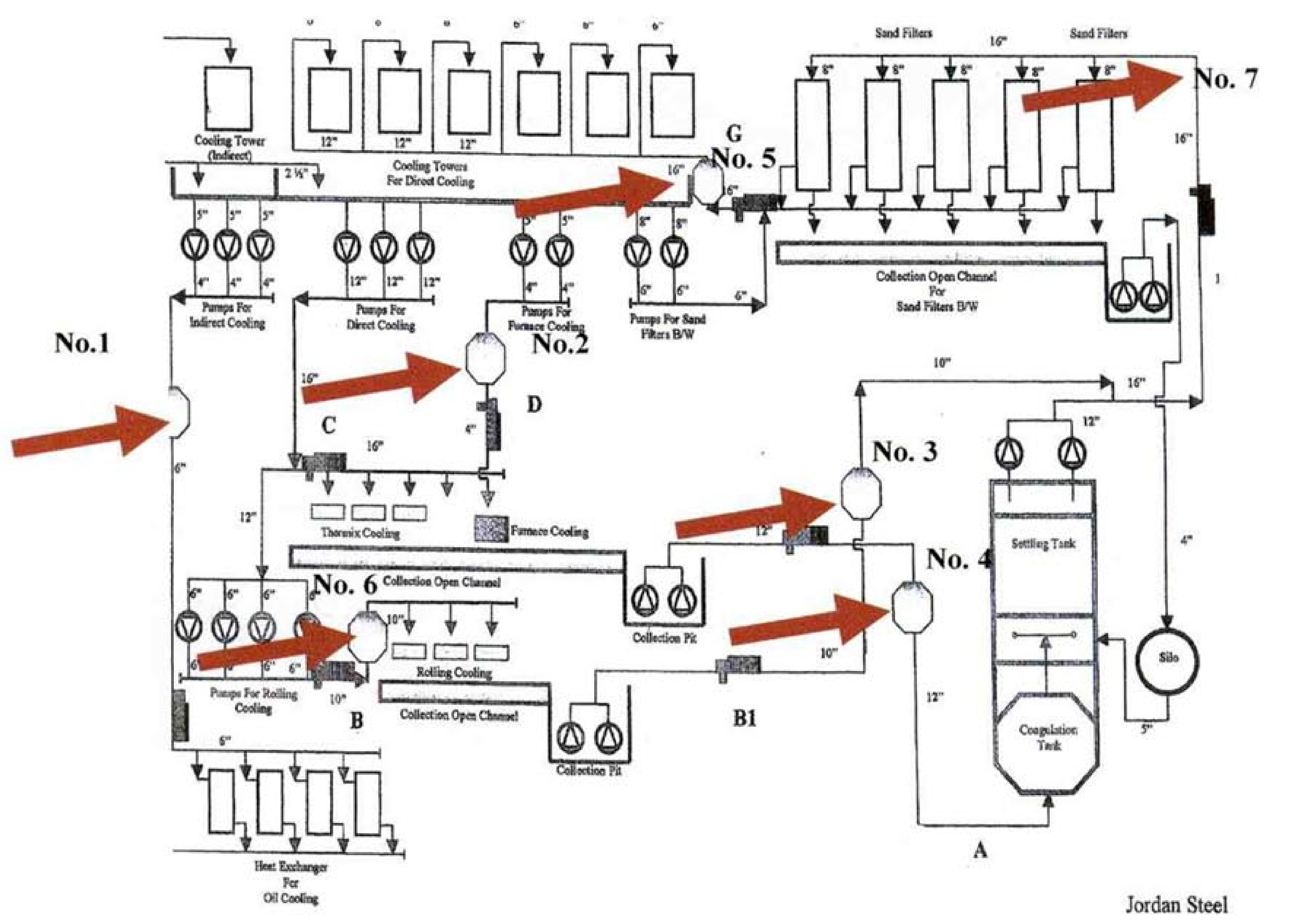


Fig.(2) Arrows refer to the positions of corrosion and scale coupons in JSF cooling water piping network.

Consultant:Dr.Farqad F.M.Saeed F.F. Saeed Consultant:Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN AND TECHNOLOGY CENTER
Corrosion Engineering Division
P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276
Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

Designation No.: 3/05/1819	Our Ref. & Date:	(3)148/55/1/22467	Date10/9/2006
	Method of Sampling:		
	Date of Test:		

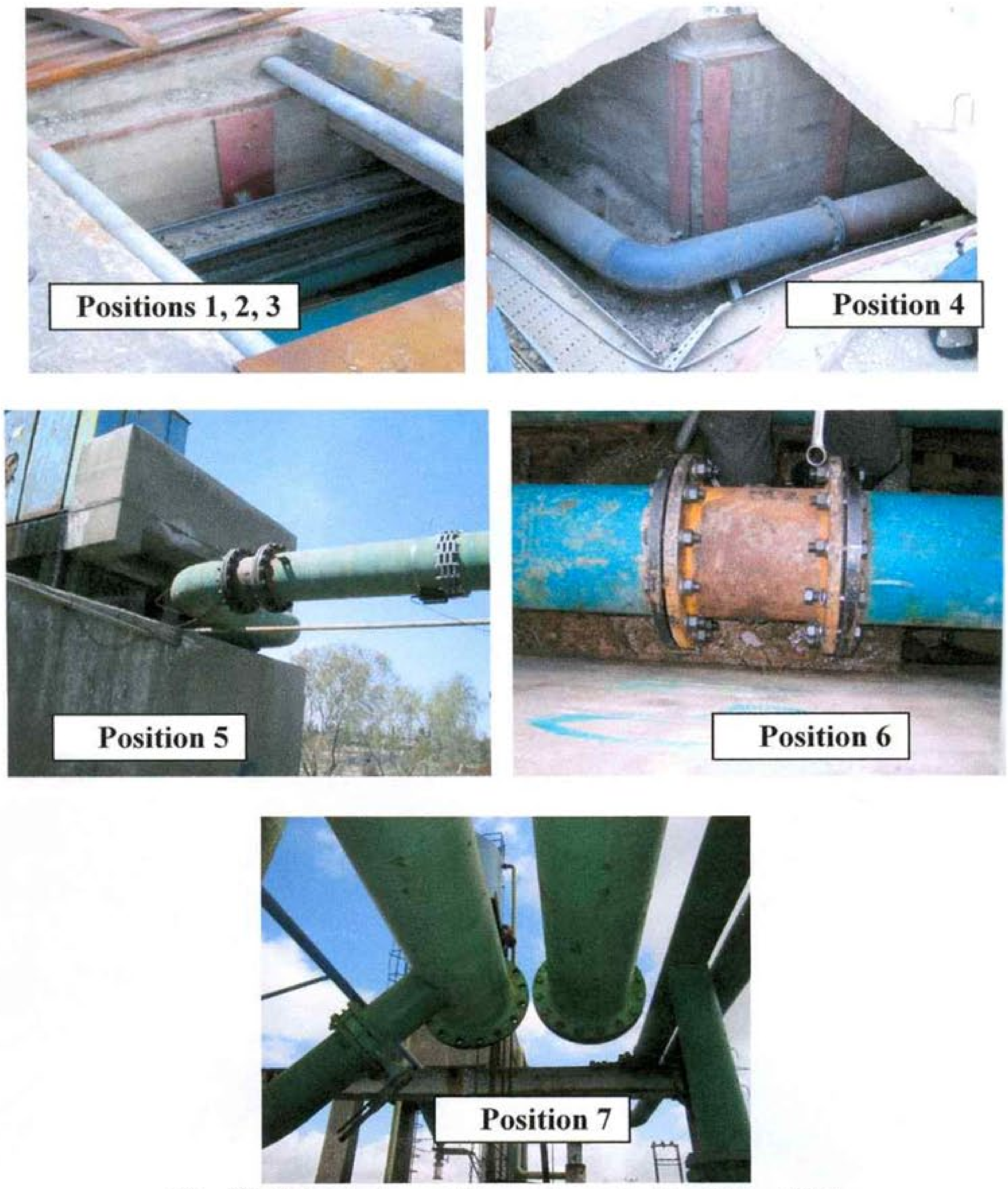


Fig.(3) Selected positions given in fig.(2) in JSF.

Consultant:Dr.Farqad F.M.Saeed F.F. Saeed Consultant:Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN &
TECHNOLOGY CENTRE

FORM NO. RSSPMP1302 | REV. (1)

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN AND TECHNOLOGY CENTER
Corrosion Engineering Division
P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276
Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

Designation No.: 3/05/1819	Our Ref. & Date:	(3)148/55/1/22467	Date10/9/2006
	Method of Sampling:		
	Date of Test:		

CC No5(carbon steel)

SC No11(NAS64)

Fig.(4):Shows the installation of the Corrosion Coupon and Scale Coupon in Position No. 1(6 inch)

Consultant:Dr.Farqad F.M.Saeed F.F. Saeed Consultant:Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN &
TECHNOLOGY CENTRE

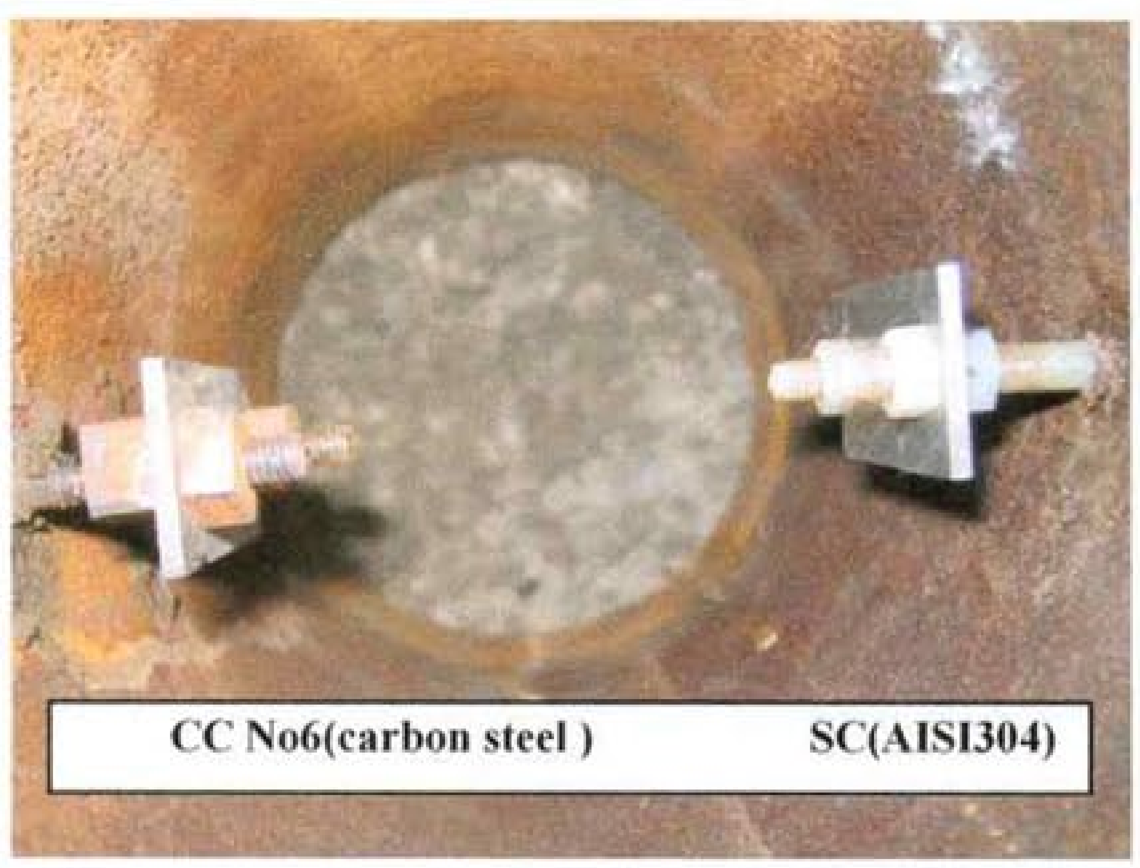
FORM NO. RSSPMP1302 | REV. (1)

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN AND TECHNOLOGY CENTER
Corrosion Engineering Division
P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276
Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

Designation No.:	3/05/1819	Our Ref. & Date:	(3)148/55/1/22467 Date 10/9/2006
		Method of Sampling:	
		Date of Test:	

Inside of the pipe



CC No6(carbon steel) SC(AISI304)

Fig.(5): Shows the installation of the Corrosion Coupon and Scale Coupon in Position No. 2(4 inch)

Consultant:Dr.Farqad F.M.Saeed F.A. Saeed Consultant:Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN &
TECHNOLOGY CENTRE

FORM NO. RSSPMP1302 | REV. (1)

ROYAL SCIENTIFIC SOCIETY

MECHANICAL DESIGN AND TECHNOLOGY CENTER

Corrosion Engineering Division

P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276

Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

Designation No.:	3/05/1819	Our Ref. & Date:	(3)148/55/1/22467 Date10/9/2006
		Method of Sampling:	
		Date of Test:	

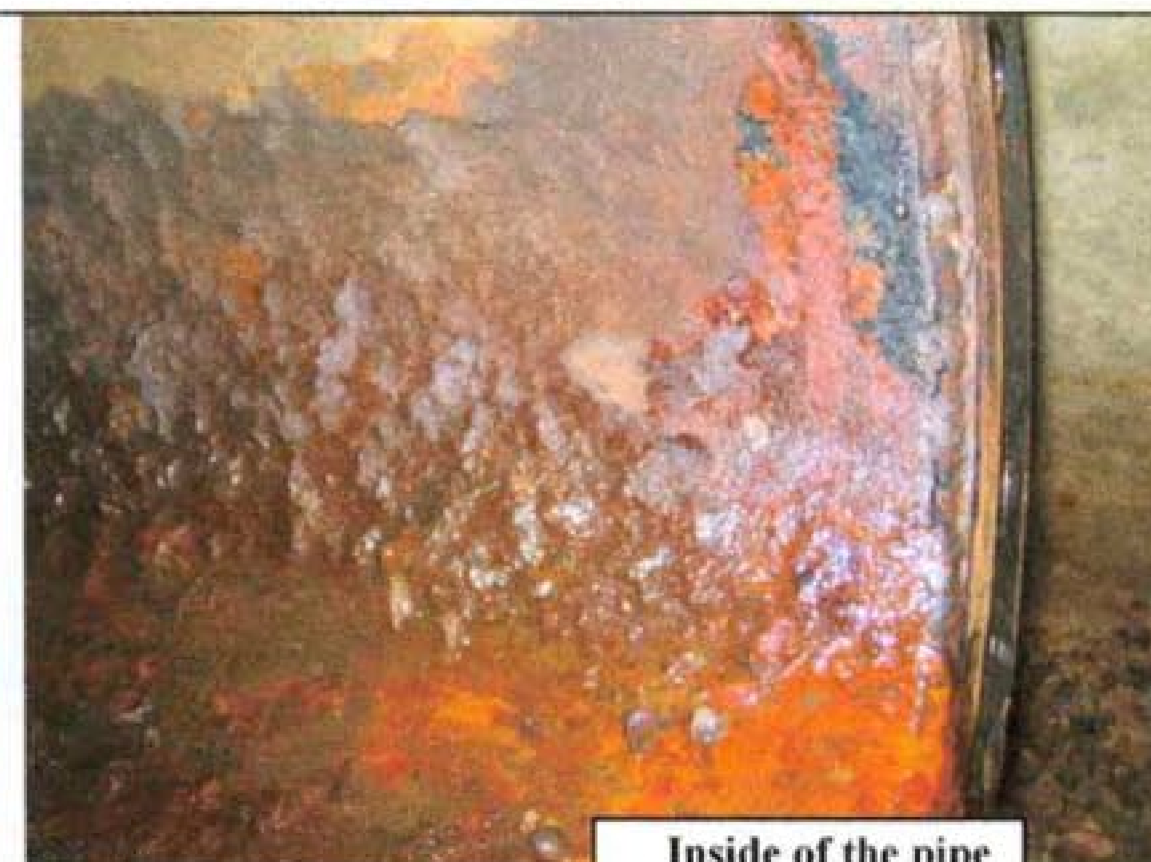


Fig.(6): Shows the installation of the Corrosion Coupon and Scale Coupon in Position No.3(10 inch)

Consultant:Dr.Farqad F.M.Saeed F.F. Saeed Consultant:Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN &
TECHNOLOGY CENTRE

FORM NO. RSSPMP1302 | REV. (1)

ROYAL SCIENTIFIC SOCIETY

MECHANICAL DESIGN AND TECHNOLOGY CENTER

Corrosion Engineering Division

P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276

Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

Designation No.:	3/05/1819	Our Ref. & Date:	(3)148/55/1/22467 Date10/9/2006
		Method of Sampling:	
		Date of Test:	

Fig.(7): Shows the installation of the Corrosion Coupon and Scale Coupon in Position No.4 (12inch)

Consultant:Dr.Farqad F.M.Saeed F.F. Saeed Consultant:Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN &
TECHNOLOGY CENTRE

FORM NO. RSSPMP1302 | REV. (1)

ROYAL SCIENTIFIC SOCIETY

MECHANICAL DESIGN AND TECHNOLOGY CENTER

Corrosion Engineering Division

P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276

Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

Designation No.: 3/05/1819		Our Ref. & Date:	(3)148/55/1/22467 Date10/9/2006
		Method of Sampling:	
		Date of Test:	

Fig.(8): Shows the installation of the Corrosion Coupon and Scale Coupon in Position No.5 (16 inch)

Consultant:Dr.Farqad F.M.Saeed F. F. Saeed | Head of Division: Dr.Azzam A.Odeh

Consultant:Dr.M.Tsuda

Masaomi Tsuda

Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY MECHANICAL DESIGN & TECHNOLOGY CENTRE

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN AND TECHNOLOGY CENTER
Corrosion Engineering Division
P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276
Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

Designation No.:	3/05/1819	Our Ref. & Date:	(3)148/55/1/22467	Date 10/9/2006
		Method of Sampling:		
		Date of Test:		

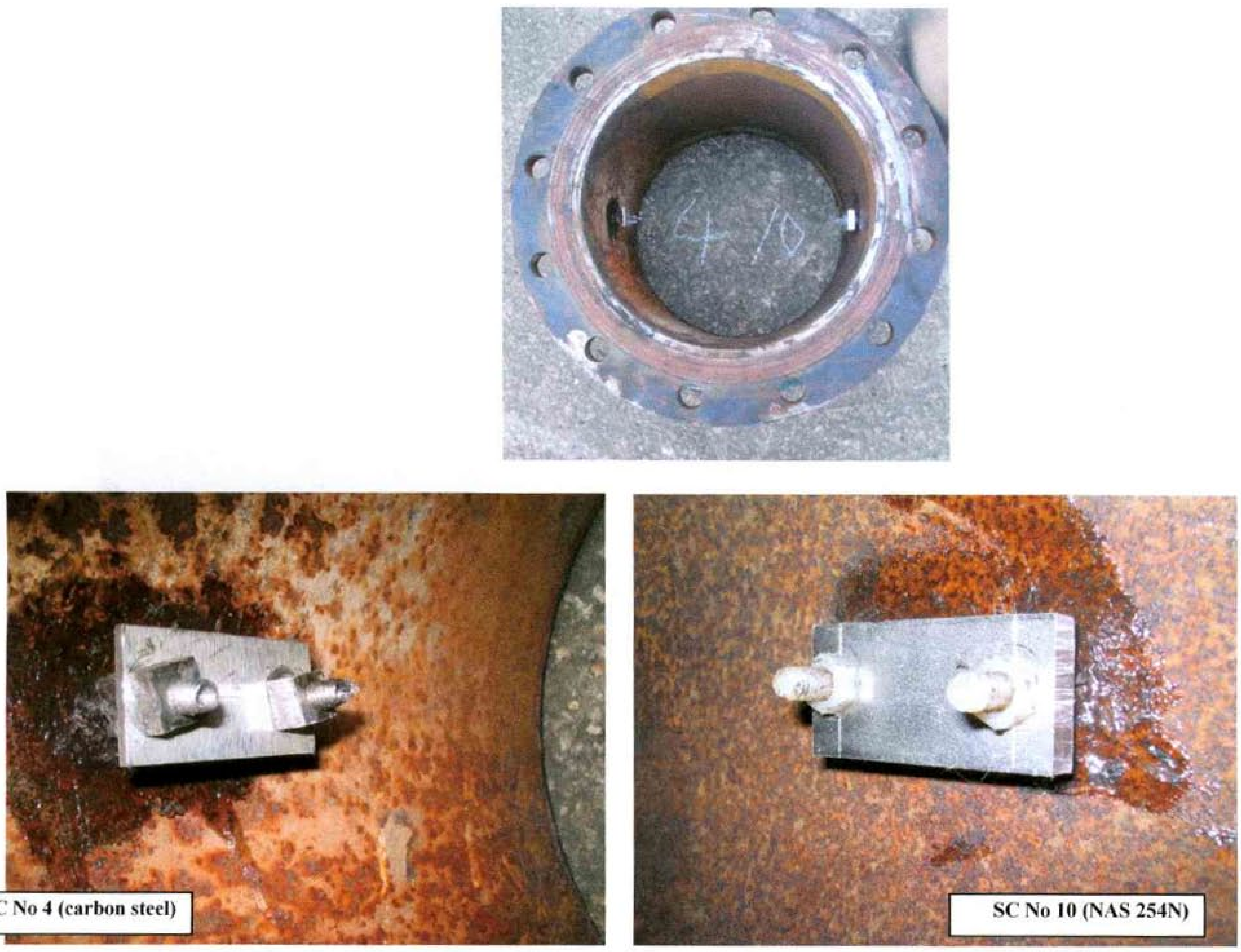


Fig.(9): Shows the installation of the Corrosion Coupon and Scale Coupon in Position No.6(10 inch)

Consultant:Dr.Farqad F.M.Saeed F.F. Saeed Consultant:Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN &
TECHNOLOGY CENTRE

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN AND TECHNOLOGY CENTER
Corrosion Engineering Division
P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276
Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

Designation No.: 3/05/1819		Our Ref. & Date:	(3)148/55/1/22467 Date/09/2006
		Method of Sampling:	
		Date of Test:	

Fig.(10): Shows the installation of the Corrosion Coupon and Scale Coupon in Position No.7(16 inch)

Consultant:Dr.Farqad F.M.Saeed Consultant:Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN &
TECHNOLOGY CENTRE

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN AND TECHNOLOGY CENTER
Corrosion Engineering Division
P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276
Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

Designation No.: 3/05/1819	Our Ref. & Date:	(3)148/55/1/22467	Date10/9/2006
	Method of Sampling:		
	Date of Test:		

Chemical analysis of the products existing on the surface of the piping network revealed high quantities (60-70 %) of FeO, $Fe(OH)_2$ and Fe_3O_4 combined with greasy material before installing the corrosion and scale coupons to the piping network.
Chemical analysis of the Well water,Indirect cooling system and Direct cooling system revealed quantities of SULFATE REDUCING BACTERIA (SRB) before installing the corrosion and scale coupons to the piping network.
Randomly selected position (position no.3) was opened after 3 months (7/4/2006) in order to conduct visual inspection without removing the coupons from its location as shown in fig.(11). Visual inspection revealed traces of brownish products on the surface of the corrosion coupon as well as the surface of the pipe.

Fig.(11): Visual inspection of the Corrosion coupon (to the left) and scale coupon (to the right)

Consultant:Dr.Farqad F.M.Saeed F. F. Saed Consultant:Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN & TECHNOLOGY CENTRE

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN AND TECHNOLOGY CENTER
Corrosion Engineering Division
P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276
Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

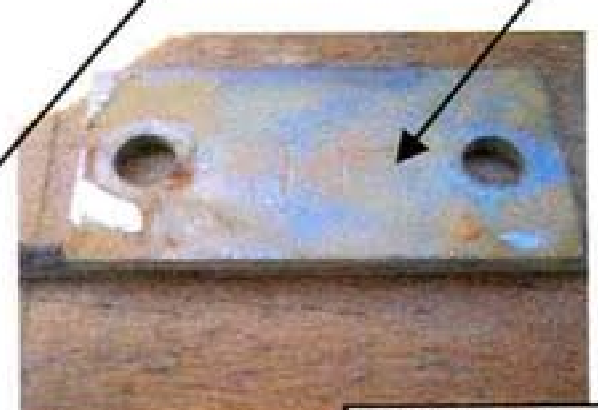
Designation No.:	3/05/1819	Our Ref. & Date:	(3)148/55/1/22467 Date10/9/2006
		Method of Sampling:	
		Date of Test:	

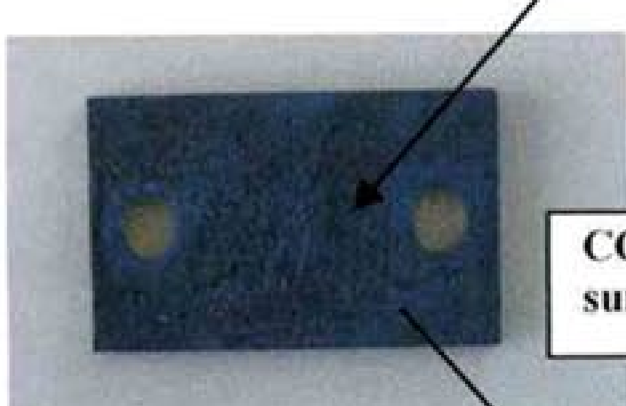
Corrosion and Scale coupons were removed from postions no.s (1 and 3) after six month of exposure (1/7/2006).The surface of the corrosion and scale coupons of position no. (1) were covered with brownish colored material . Chemical analysis of the material collected from surface of the scale coupon revealed (49-55%) iron oxides , (1-7 %) $CaCO_3$,greasy material and traces of sulfate, chloride ,magnesium ions.Corrosion rates of CC No.5 equal to 0.09 mm/y or 3.54 mpy .

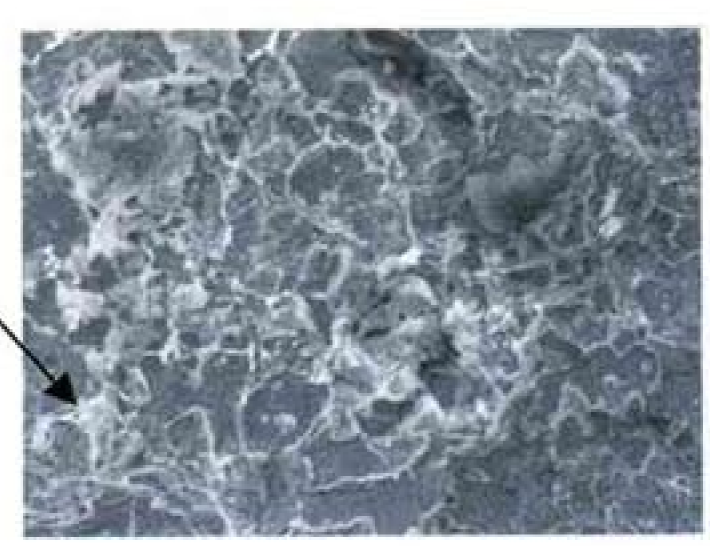

CC No.5 before exposure


SC No.11 before exposure


CC No.5 after six months


SC No.11 after six months


CC No.5 after removing products from the surface.Surface roughness wasdetected .


SEM photo of the surface of CC No.5 after removing products from the surface.

Consultant:Dr.Farqad F.M.Saeed A.A-Saeed
Consultant:Dr.M.Tsuda
Masaomi Tsuda

Head of Division: Dr.Azzam A.Odeh
Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN &
TECHNOLOGY CENTRE

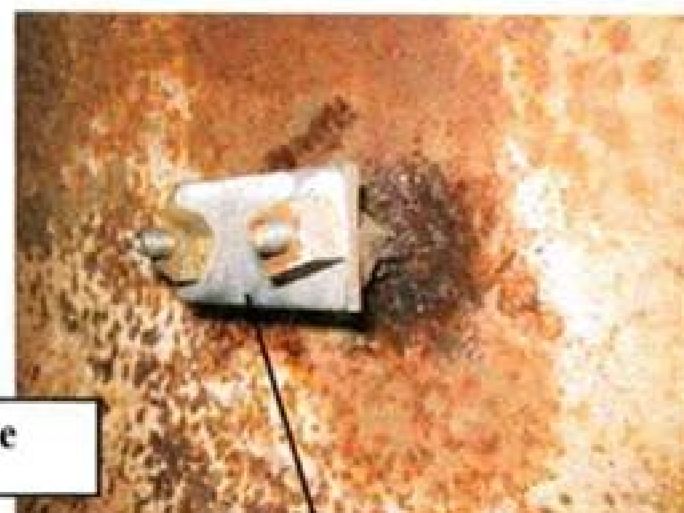
FORM NO. RSSPMP1302 | REV. (1)

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN AND TECHNOLOGY CENTER
Corrosion Engineering Division
P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276
Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

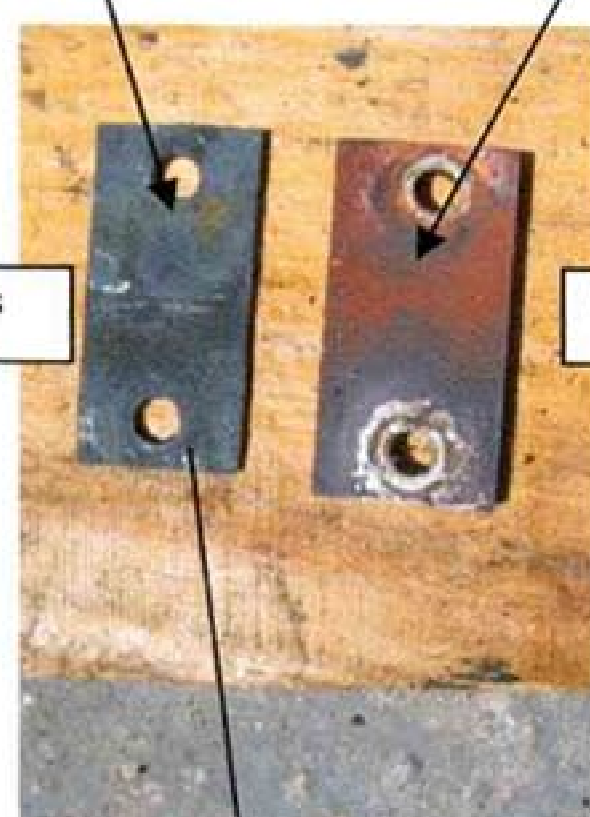
Designation No.: 3/05/1819	Our Ref. & Date: (3)148/55/1/22467 Date10/9/2006 Method of Sampling: Date of Test:

The surface of the corrosion and scale coupons of position no. (3) were covered with brownish colored material . Chemical analysis of the material collected from surface of the scale coupon revealed (45%) iron oxides , (45 %) $CaCO_3$,greasy material and traces of sulfate, chloride ,magnesium ions.Corrosion rates of CC No.3 equal to 0.4807 mm/y or 18.925 mpy.



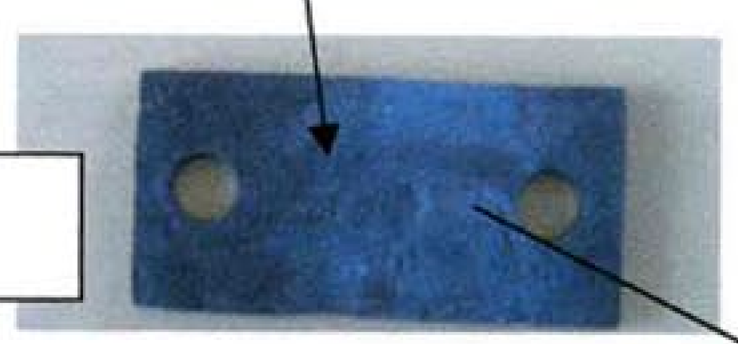
CC No.3 before exposure

SC No.9 before exposure

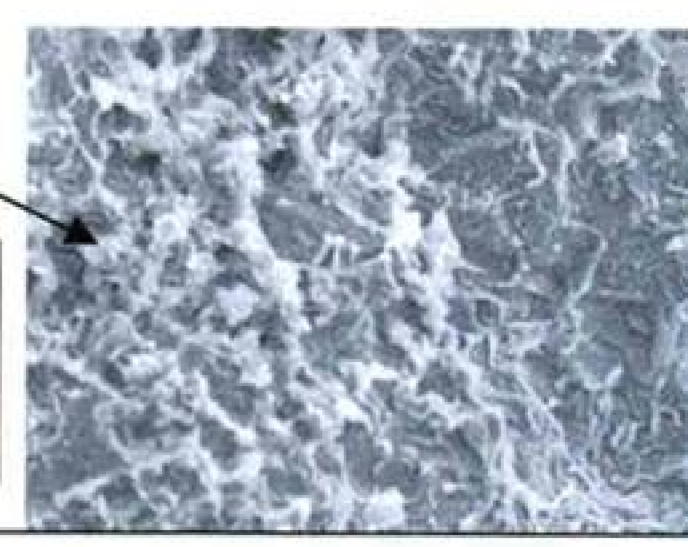


CC No.3 after six months

SC No.9 after six months



CC No.3 after removing products from the surface.Surface roughness wasdetected .



SEM photo of the surface of CC No.3 after removing products from the surface.

Consultant:Dr.Farqad F.M.Saeed Consultant:Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN & TECHNOLOGY CENTRE

ORM NO. RSSPMP1302 | REV. (1)

ROYAL SCIENTIFIC SOCIETY

MECHANICAL DESIGN AND TECHNOLOGY CENTER
Corrosion Engineering Division
P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276
Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

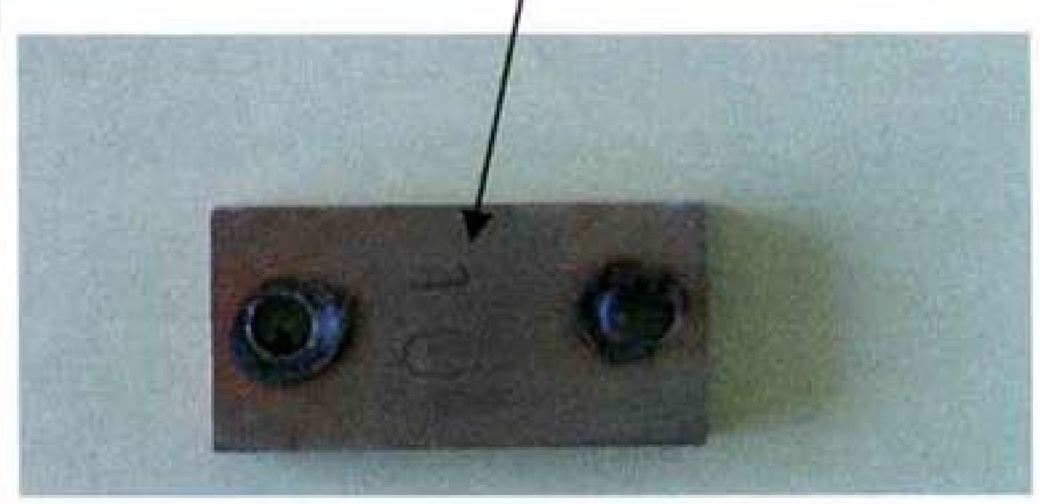
Designation No.:	3/05/1819	Our Ref. & Date:	(3)148/55/1/22467 Date10/9/2006
		Method of Sampling:	
		Date of Test:	

Corrosion and Scale coupons were removed from postion no.(6) after seven month of exposure (1/8/2006).The surface of the corrosion and scale coupons of position (6) were covered with brownish colored material .Chemical analysis of the material collected from surface of the scale coupon revealed (41-52%) iron oxides , (20 %) $CaCO_3$,greasy material and traces of sulfate, chloride ,magnesium ions.Corrosion rates of CC No.4 equal to 0.1337mm/y or 5.26 mpy.

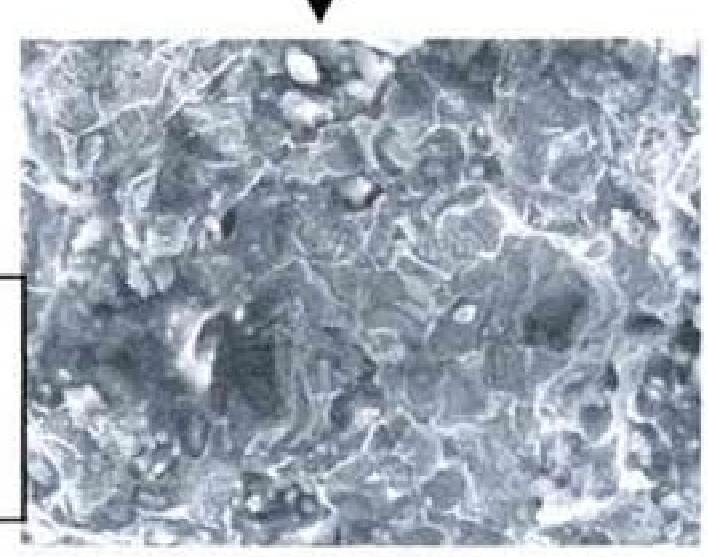
CC No.4 before exposure

SC No.10 before exposure

CC No.4 after removing products from the surface.Surface roughness wasdetected .Seven monts of exposure



SC No.10 after seven months



SEM photo of the surface of CC No.4 after removing products from the surface.

Consultant:Dr.Farqad F.M.Saeed F.F. Saeed Consultant:Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN &
TECHNOLOGY CENTRE

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN AND TECHNOLOGY CENTER
Corrosion Engineering Division
P.O. Box 1438 Jubaiha 11941, Amman - Jordan, Telex:21276
Fax : (962)6-5344806, Phone : (962)6-5344701-9

TEST REPORT NO 351/06/5

Designation No.:	3/05/1819	Our Ref. & Date:	(3)148/55/1/22467	Date10/9/2006
		Method of Sampling:		
		Date of Test:		

EVALUATION:

Corrosion phenomena existed due to the presence of the following **Three** factors : Iron oxides ,scaling and SULFATE REDUCING BACTERIA (SRB) .Iron oxide precipitations formed concentration cells which caused the corrosion phenomena to occur in addition to the existence of SRB . SRB is an anaerobic bacteria which reduces (SO_3) to sulfide and forming H_2S gas under the scaling film (H_2S gas is considered a very aggressive corrosive media).

Corrosion rate results of CC No.s (3 & 4) located in direct cooling system showed higher values than CC No.(5) located in indirect cooling system due to the presence of higher percentages of scaling in addition to iron oxide precipitations and oxygen content. Corrosion rate results of CC 4 No.4 (exposure time equal to SEVEN months)is (5.26 mpy) which is less than the corrosion rate of CC No.3 (exposure time equal to SIX months) (18.925 mpy), which means that corrosion rate results are improving with time due to the performance of HYDROFLOW TECHNOLOGY.In addition to the above iron oxide percentages on the surface became lower with time because chemical analysis of the products collected from the internal surface of the pipes on 4/1/2006 showed iron oxide percentages equal to (60-70 %) while the chemical analysis of the products collected from the internal surface of the pipes on 1/8/2006 showed iron oxide percentages equal to (49 %) , which means that iron oxide percentages are becoming lower with time due to the performance of HYDROFLOW TECHNOLOGY which will be reflected posetively on reducing the rate of corrosion .On the other hand scaling percentages of SC No.10 (20 % of total products on the surface of the coupon) which is less than the scaling percentages of SC No.9 (45 % of total products on the surface of the coupon) although the exposure time of SC No.10 is SEVEN months while SC No.9 is SIX months, which means that scaling percentages are becoming lower with time due to the performance of HYDROFLOW TECHNOLOGY which will also be reflected positively on reducing the rate of corrosion.

Consultant:Dr.Farqad F.M.Saeed F.F.Saeed Consultant:Dr.M.Tsuda Masaomi Tsuda	Head of Division: Dr.Azzam A.Odeh Dr. A. Odeh

ROYAL SCIENTIFIC SOCIETY
MECHANICAL DESIGN &
TECHNOLOGY CENTRE