

Contents	Page
1 Introduction.....	1
2 Scope and Purpose.....	1
2.1 Scope	1
2.2 Purpose	1
3 Definitions.....	2
4 Description of syngas outlet systems	4
4.1 General description and overview	4
4.2 Hot outlet systems	5
4.3 Cold outlet systems	6
4.4 Materials of construction.....	8
5 Failure modes.....	9
5.1 Metal dusting	9
5.2 Thermal aging.....	9
5.3 Thermal fatigue.....	10
5.4 Creep.....	10
5.5 Excessive stress.....	11
5.6 Stress corrosion cracking	11
5.7 Stress relaxation cracking	11
5.8 High temperature hydrogen attack	12
5.9 Hydrogen embrittlement	12
5.10 Material deformation due to high temperature (bulging at hot spots)	12
5.11 Nitridation and carburization.....	12
5.12 Insulation failure	13
5.13 Summary of failure modes and components.....	13
6 Monitoring and inspection during plant operation.....	14
6.1 General and safety considerations	14
6.2 Visual observations	15
6.3 Outlet system temperature monitoring	16
7 Online remedial action.....	17
7.1 Temperature balancing of furnace.....	17
7.2 Temperature mitigation (cooling hot spots)	17
8 Offline maintenance and inspection	18
8.1 Hot collector (inside of furnace) and hot pigtails (inside of furnace or outside of furnace/ externally insulated)	18
8.2 Connection of tube to cold collector or hot collector to transition line.....	20
8.3 Refractory lined pipe.....	21
9 References	23
 Figures	
Figure 1—Reformer furnace with cold collector	5
Figure 2—Reformer furnace with hot collector.....	6
Figure 3—Cold pigtail design	7
Figure 4—Hot pigtail design.....	7
Figure 5—Variations in syngas outlet pigtails	8
Figure 6—Example of metal dusting	9
 Tables	
Table 1—Threshold temperature for creep	10
Table 2—Failure modes associated with syngas outlet system components	14