

## **February 2024 ASHRAE Journal**

**The following pages contain supplementary information for these articles in the February 2024 issue of ASHRAE Journal**

- **Higher-Efficiency Redundancy Strategy for Data Center Cooling, Page 2**
- **Accelerated Degradation Of Copper Cold Plates in Direct-to-Chip Liquid Cooling in Data Centers, Page 3–10**

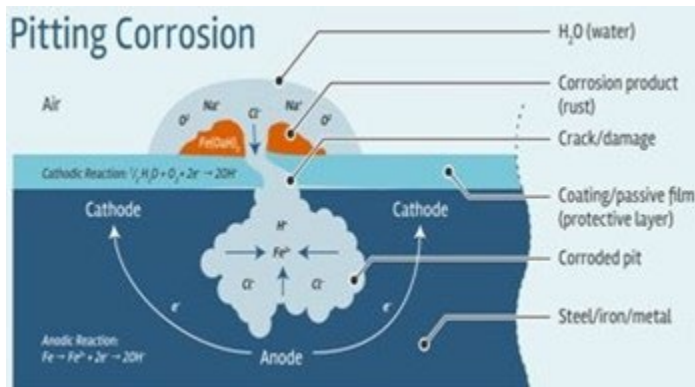
# Higher-Efficiency Redundancy Strategy for Data Center Cooling

By Jinkyun Cho, Ph.D., Member ASHRAE; Jinyoung Lee, P.E., Member ASHRAE

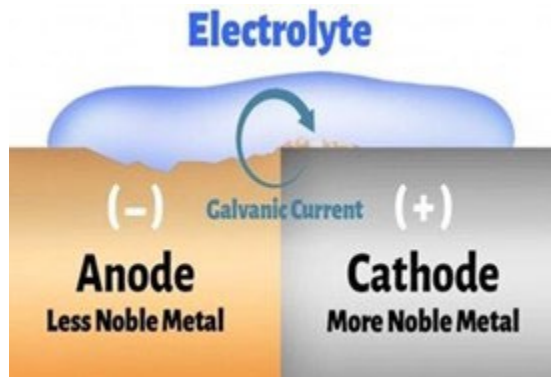
ONLINE TABLE 1 Technical specification data of the cooling unit.						
FAN WALL UNITS (N + 2 PER MODULE): TOTAL 120 EA						
Quantity Redundancy, EA	Cooling Capacity, kW	Airflow Rate, m <sup>3</sup> /h	Waterside Temperature, °C		Airside Temperature, °C	
			Inlet	Outlet	Supply Air	Return Air
100 + (20 redundancy)	345	78,500	18	28	24	36
WATER COOLED CENTRIFUGAL CHILLER (N + 1): TOTAL 6 EA						
Quantity Redundancy EA	Cooling Capacity, kW	Water Flow Rate, L/min	Chilled Water Temperature, °C		Condenser Water Temperature, °C	
			Supply Water	Return Water	Supply Water	Return Water
5 + (1 Redundancy)	7,050	10,082	28.0	18.0	27.0	36.3
OPEN CIRCUIT, INDUCED-DRAFT CROSS FLOW COOLING TOWER (N + 1): TOTAL 6 EA						
Quantity Redundancy EA	Cooling Capacity, kW	Water Flow Rate, L/min	Condenser Water Temperature, °C		Wet-Bulb Temperature, °C (Summer Outdoor Air)	
			Supply Water	Return Water	29.3	36
5 + (1 Redundancy)	8,836	22,440	36.3	27.0	29.3	36
CHILLED WATER PUMP - COOLING WATER LEAVING THE CHILLER (N + 1): CENTRIFUGAL/VERTICAL INLINE / TOTAL: 6 EA						
Quantity Redundancy EA	Pressure Head, kPa	Water Flow Rate, L/min	Rated Speed, rpm	Efficiency, %	Speed Control	
5 + (1 Redundancy)	524	10,082	1,787	83.6	VSD/Pump Inverter	
CONDENSER WATER PUMP (N + 1): CENTRIFUGAL/VERTICAL INLINE / TOTAL 6 EA						
Quantity Redundancy EA	Pressure Head, kPa	Water Flow Rate, L/min	Rated Speed, rpm	Efficiency, %	Speed Control	
5 + (1 Redundancy)	605	22,440	1,791	86.7	VSD/Pump Inverter	

# Accelerated Degradation Of Copper Cold Plates in Direct-to-Chip Liquid Cooling in Data Centers

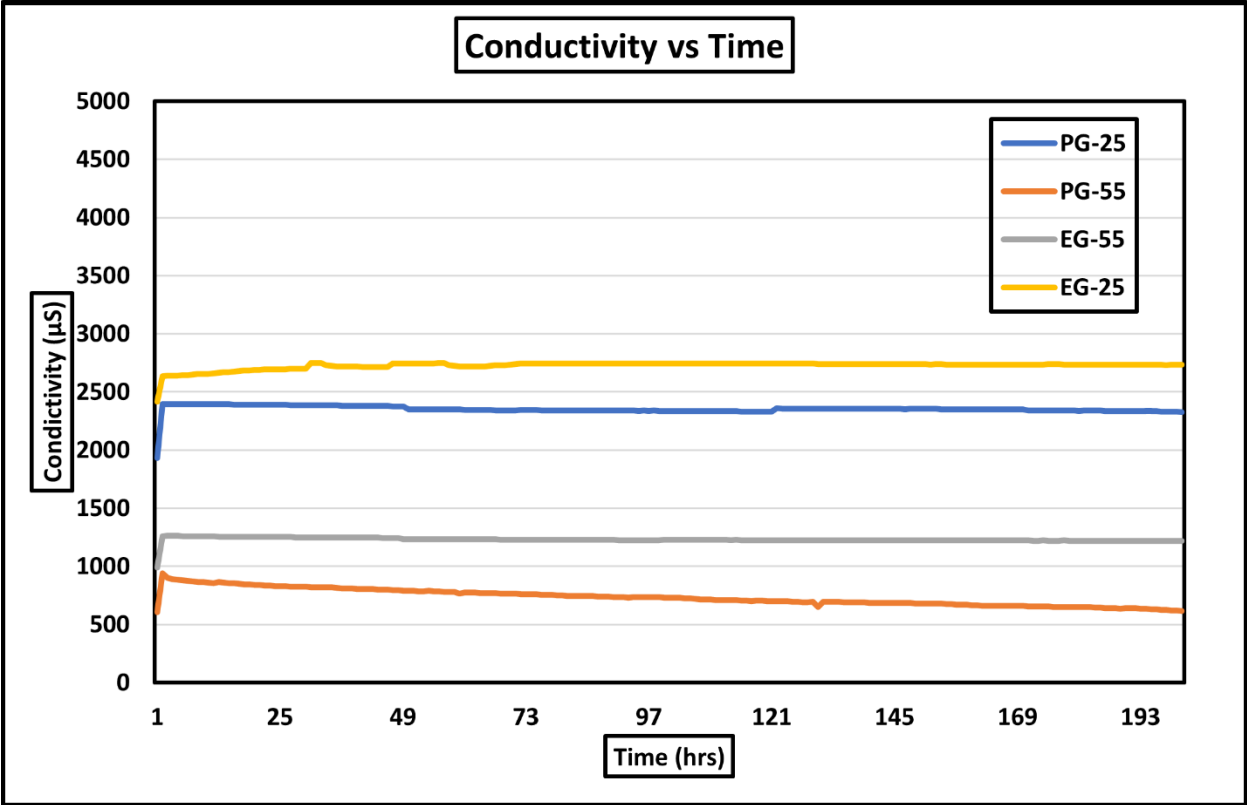
By Lochan Sai Reddy Chinthaparthi; Satyam Saini, Ph.D.; Pardeep Shahi, Ph.D.; Pratik Vithoba Bansode, Ph.D.; Himanshu Girishchandra Modi; Dereje Agonafer, Ph.D., Associate Member ASHRAE



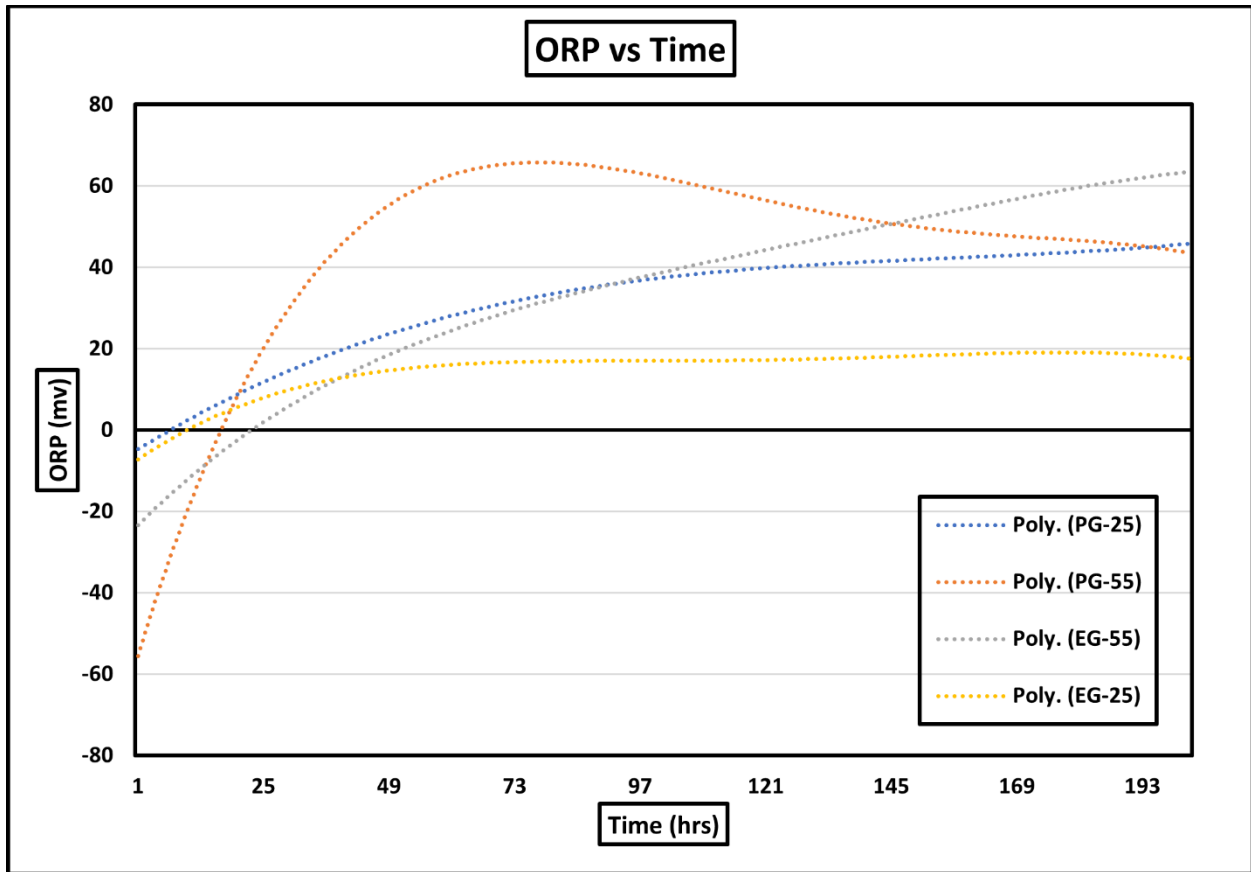
Online Figure 1: Pitting corrosion on a metal surface.



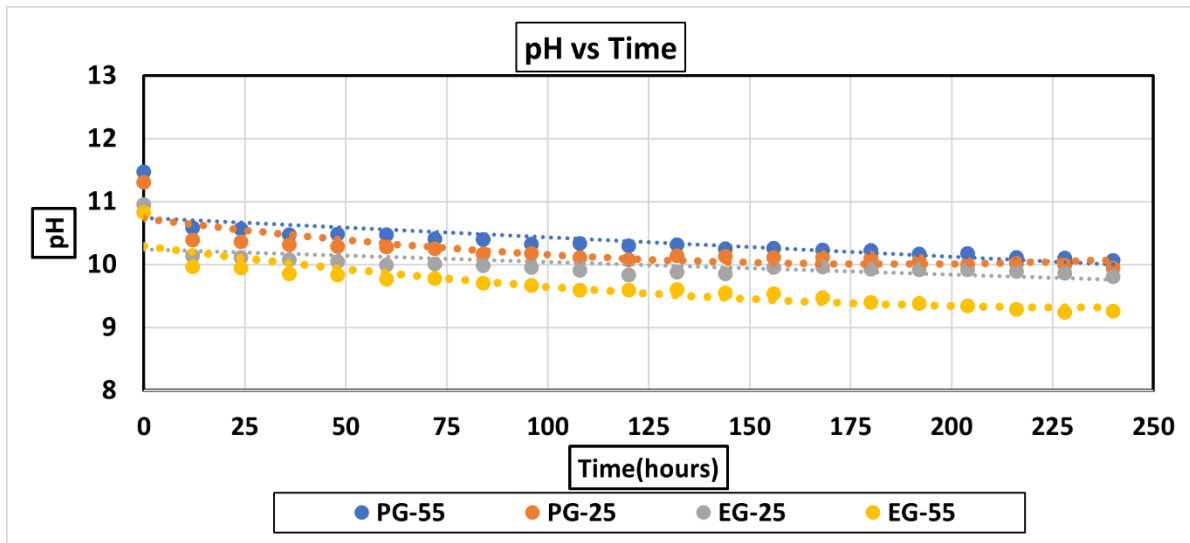
Online Figure 2: Galvanic corrosion between two dissimilar electrodes.



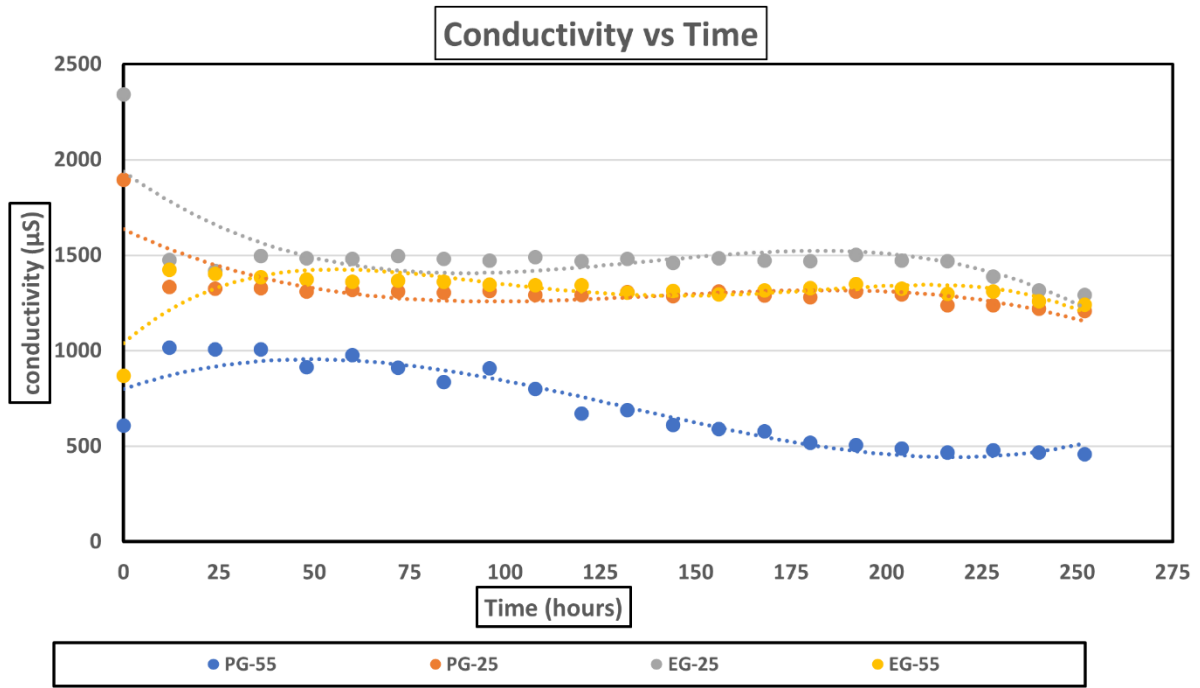
Online Figure 3: Plot showing variation in conductivity values of all test liquids for single cold plate testing.



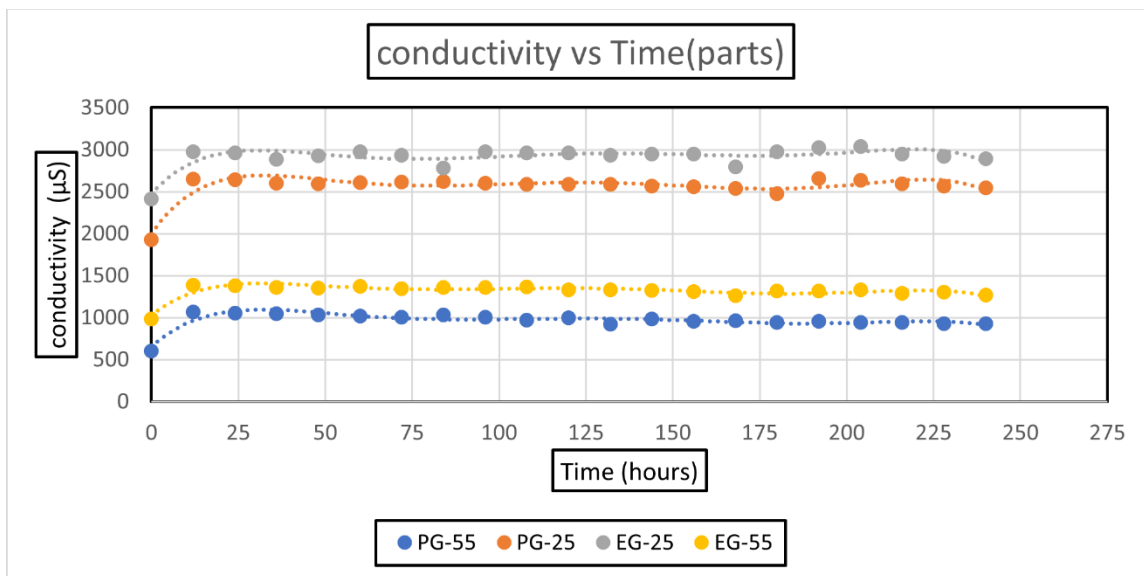
Online Figure 4: Plot showing variation in Oxidation Reduction Potential (ORP values) of all test liquids for single cold plate testing.



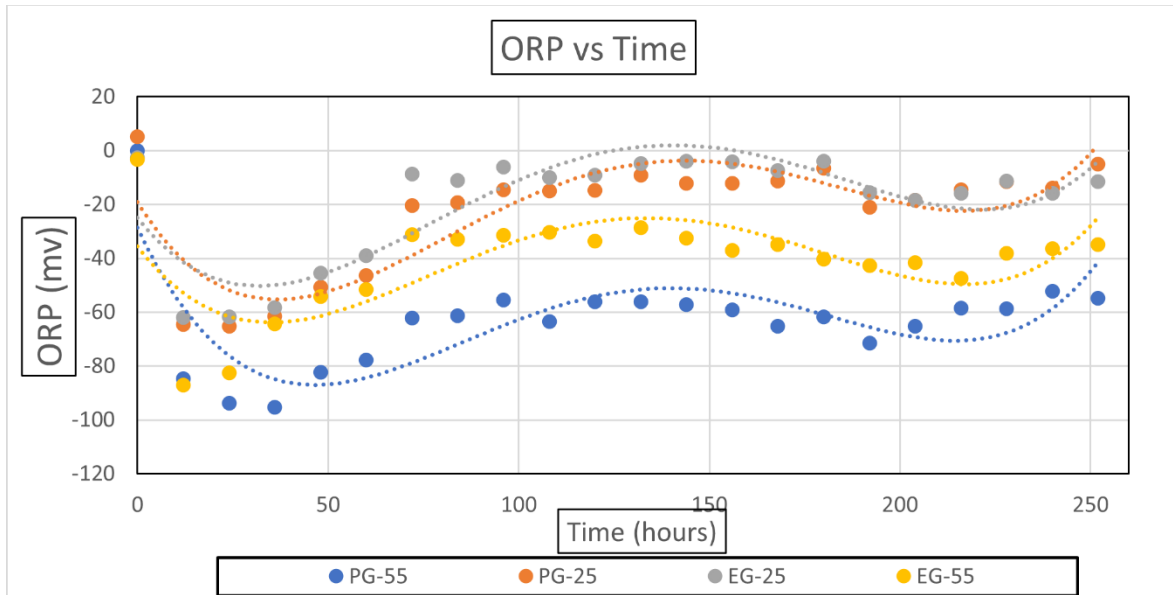
Online Figure 5: variation of pH values for test liquids with materials immersed kept in stagnation condition at the elevated environment.



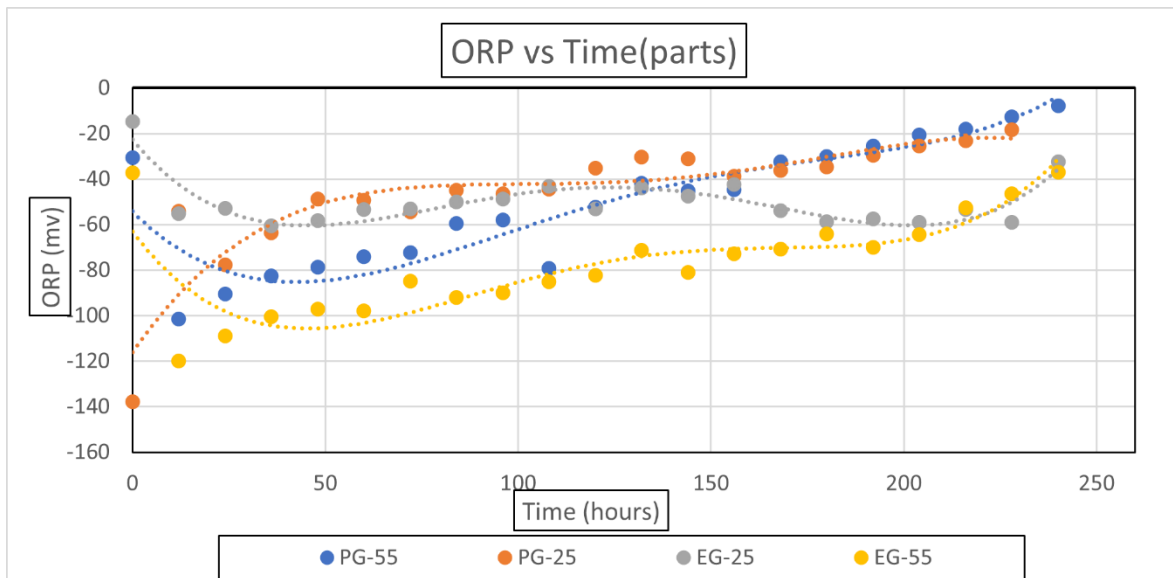
Online Figure 6: Variation of conductivity values for test liquids kept in stagnation condition at the elevated environment.



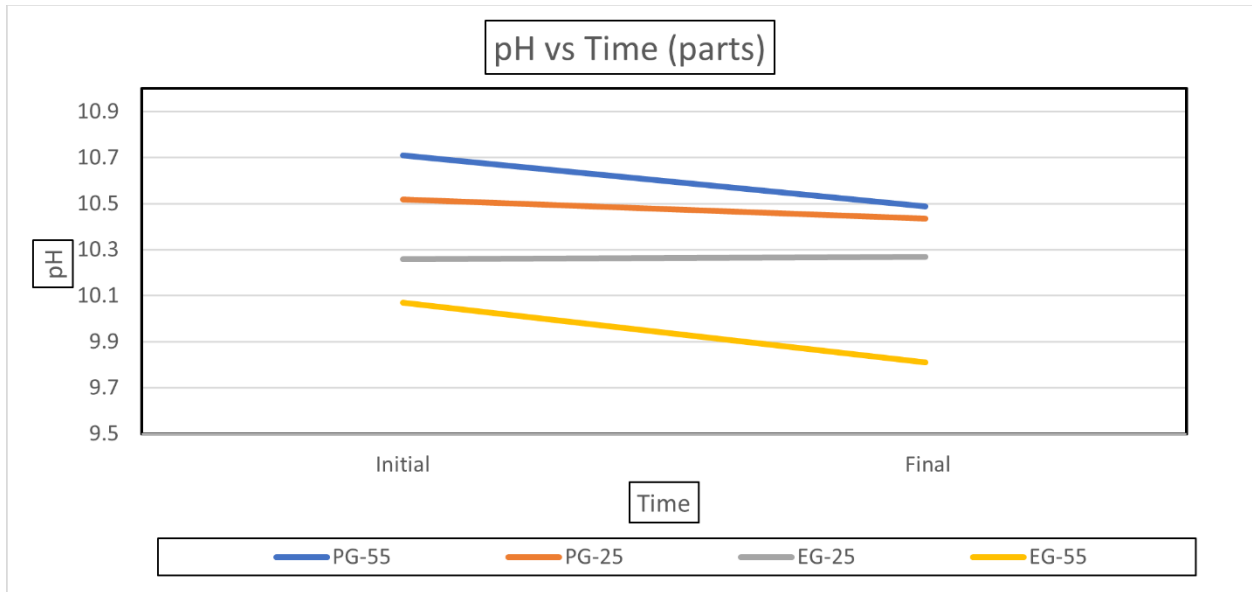
Online Figure 7: Variation of conductivity values for test liquids kept with parts immersed in stagnation condition at elevated levels.



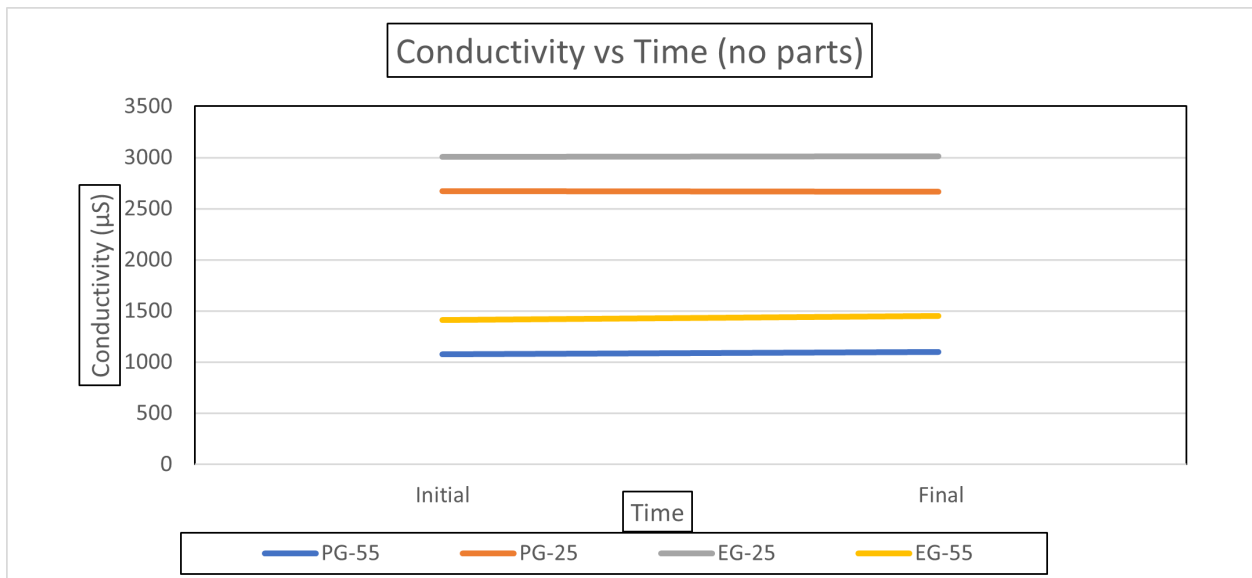
Online Figure 8: Variation of ORP values for test liquids kept in stagnation condition at elevated environment.



Online Figure 9: Variation of ORP values for test liquids with materials immersed kept in stagnation condition at the elevated environment.

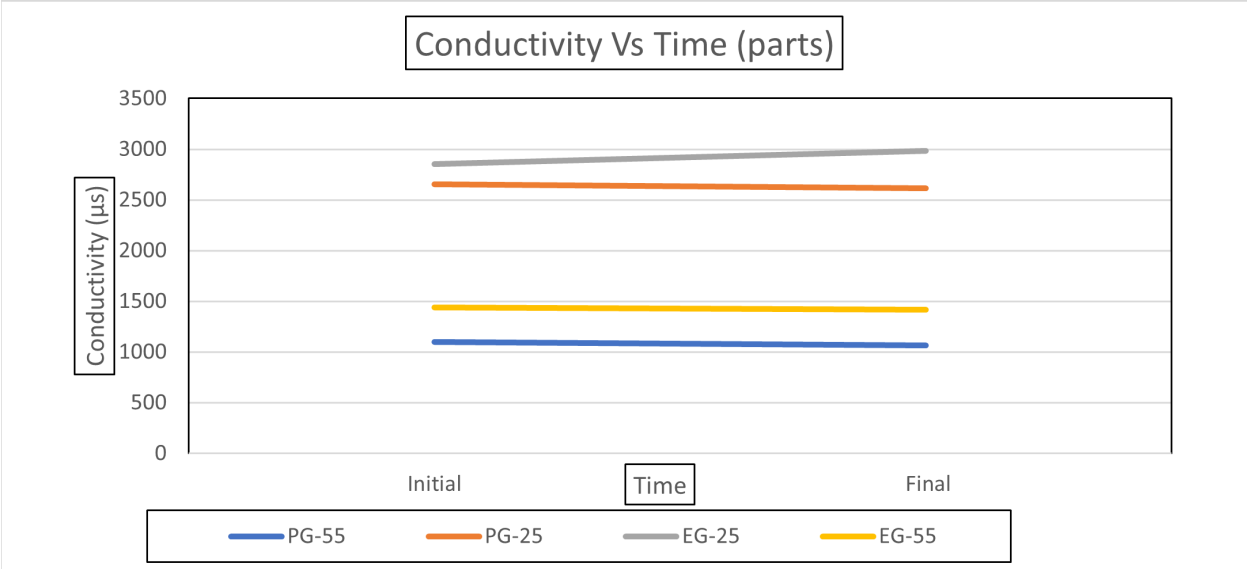


Online Figure 10: Variation of pH values for test liquids with parts immersed kept in stagnation condition at elevated environment without outside exposure.

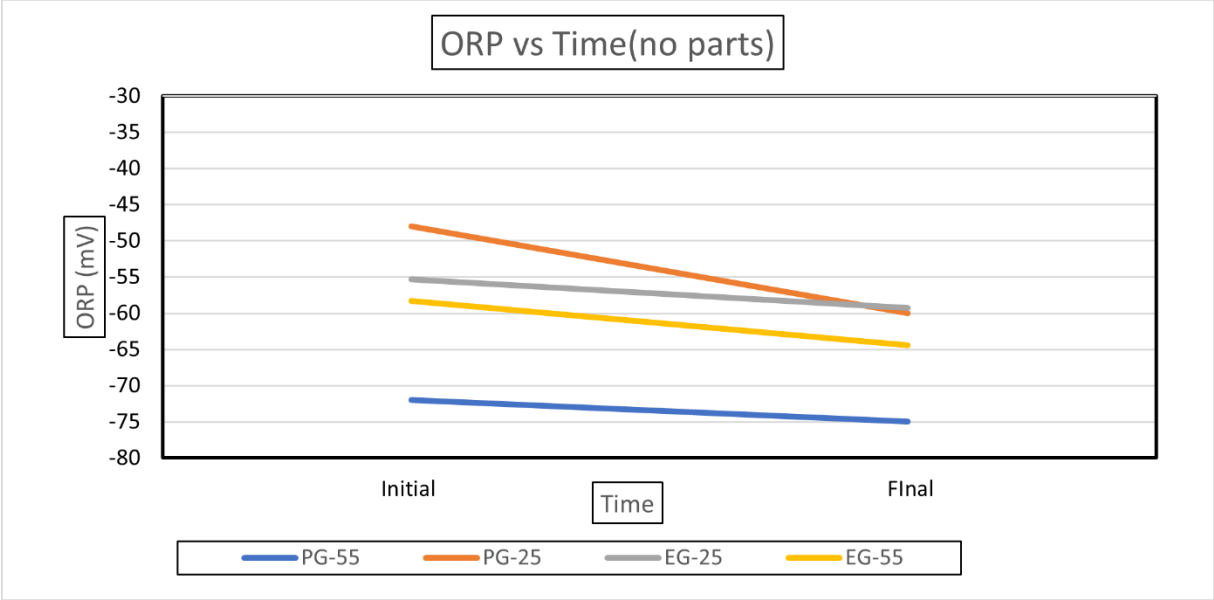


Online Figure 11: Variation of conductivity values for test liquids kept in stagnation condition at elevated environment without outside exposure.

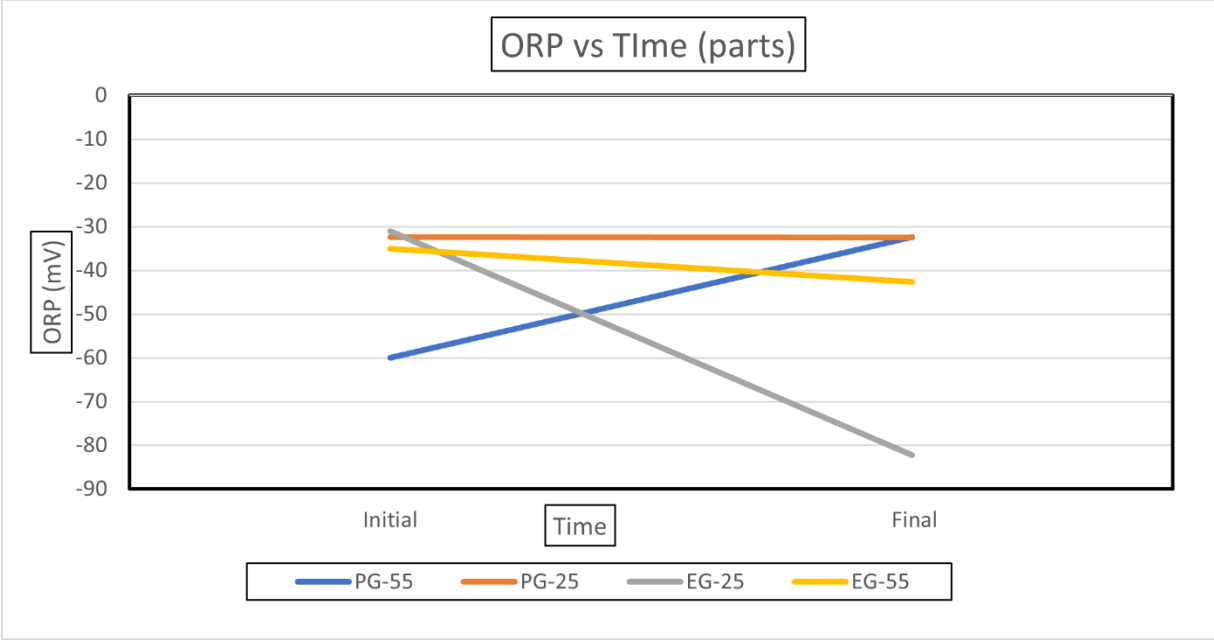




Online Figure 12: Variation of conductivity values for test liquids with materials immersed kept in stagnation condition at elevated environment without outside exposure.



Online Figure 13: Variation of ORP values for test liquids kept in stagnation condition at elevated environment without outside exposure.



Online Figure 14: Variation of ORP values for test liquids with materials immersed kept in stagnation condition at elevated environment without outside exposure.