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The Wet Power Contact Cycle

Contact Activity With Arc-Supporting Current

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The Electromechanical Life of Power Relays and Contactors

*A "**contact**" is a pair of electrodes (typically, one moving; one stationary) designed to control electricity. Power relays and contactors "turn power on" when the moving electrode (**M-electrode**) makes contact with the stationary electrode to carry current. Conversely, they "turn power off" when the **M-electrode** breaks contact and the resulting arc plasma stops burning as the dielectric gap widens sufficiently to prevent current flow (fig. I). Power relays and contactors have two primary life expectancy ratings: "**mechanical life**" is based on operating either without current or below the wetting current (i.e., "**Dry**") and "**electrical life**" is based on operating above the wetting current (i.e., "**Wet**"). These different ratings are due to contacts being designed to compensate for the destructive arcing that naturally occurs between the electrodes during normal **Wet** operation. Contact arcing is so destructive that the **electrical life** of power relays and contactors is a fraction of their **mechanical life**.*

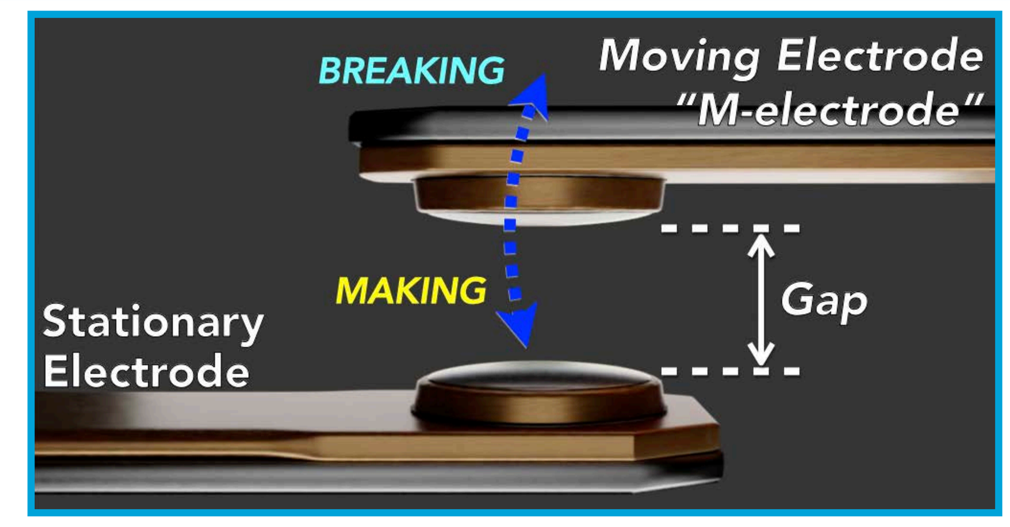

Figure I: Elements of a typical contact

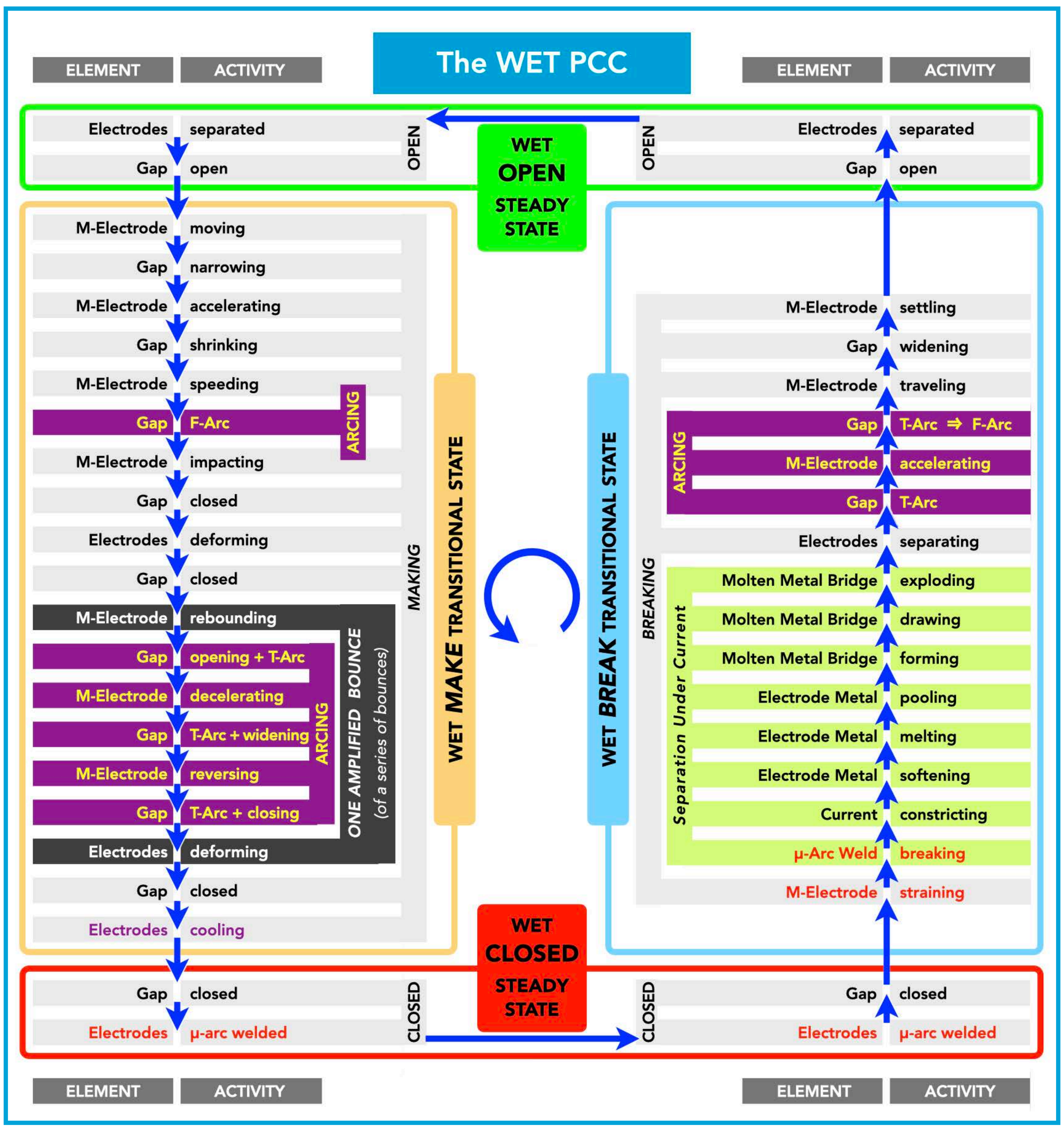

*Figure III: Abbreviated events that occur during "Wet" Power Contact Cycle transitional states of MAKE and BREAK (**NOTE**: the "BOUNCE" activities represent a single bounce of many that may occur)*

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The Wet Power Contact Cycle (**Wet PCC**) operates above the arc-supporting current (fig. II), which means the contact is subjected to contact current arcing. This arcing destroys the contacts, which foreshortens the life of a relay or contactor to its "electrical life," which is a fraction of its respective mechanical life projection.

The **Wet PCC** is comprised of four (4) distinct states: OPEN, *MAKE*, CLOSED and *BREAK* (fig. III). The transitional *MAKE* and *BREAK* states are generally of short duration, while the non-transitional OPEN and CLOSED states are generally longer in duration. During the OPEN state, voltage is present but load current is not flowing across the contact. The MAKE state starts with the **M-electrode** accelerating toward the stationary electrode, yielding a Field-emission-initiated-arc (**F-Arc**) which is terminated upon electrode impact. As the **M-electrode** rebounds, a series of MAKE-bounce Thermionic-emission-initiated arcs (**T-Arcs**) occur and **μ-arc weld** the contact electrodes together as the CLOSED state is achieved and current flows through the **μ-welded** contact-spots. As the contact cycle proceeds again through the *BREAK* state, the contact metal is drawn into a molten metal bridge, while continuing to carry current. As the **M-electrode** continues to accelerate, the super-heated molten metal bridge explodes and current is still carried by the resulting plasma. This plasma may be continued by Field-emission-initiated-arc (**F-Arc**) plasma until the gap widens beyond the current's ability to support the burning plasma. Finally the **M-electrode** settles back in the OPEN state.

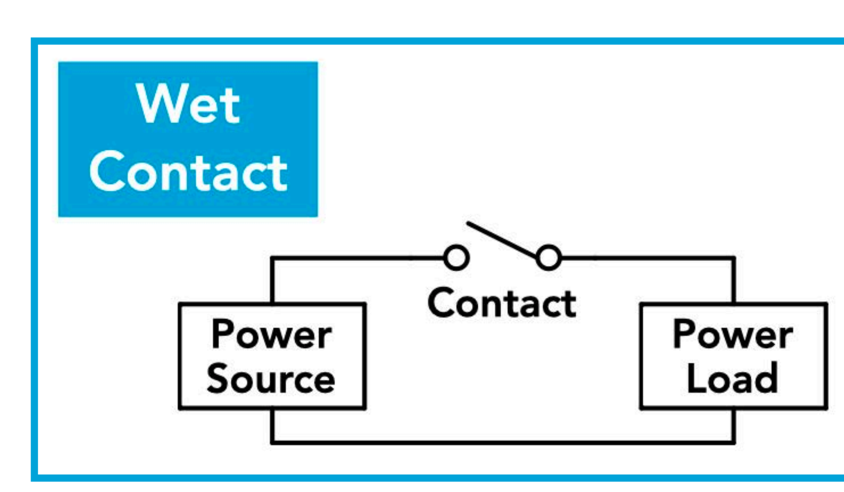

Figure II: Schematic diagram of a "Wet" contact

The Wet PCC as the "Worst Case"

Power relays and contactors are engineered to address the damaging effects of contact arcing. For example, stronger **M-electrode** armatures and springs help break-apart contacts that are welded together by *MAKE*-bounce **T-Arcs**. Similarly, arc-resistant metals and alloys slow the inevitable destruction of contact electrodes by the **T-Arcs** that occur during contact *BREAK*. Even with a more robust design, arc-inflicted contact destruction shortens an electromechanical switch's life expectancy to a fraction of its mechanical life.

Thus, the **Wet PCC** determines the electrical end-of-life projection of a power relay or contactor, as arcing will destroy a contact long before the other mechanical components of an electromechanical switch fail (fig. IV). Therefore, the **Wet PCC** establishes a "worst-case" electrical end-of-life projection for a power relay or contactor. Understanding this worst-case scenario is required for realizing how Electronic Power Contact Arc Suppression (**EPCAS**) yields an operating life that **equals** the operating life of a **Dry PCC**.

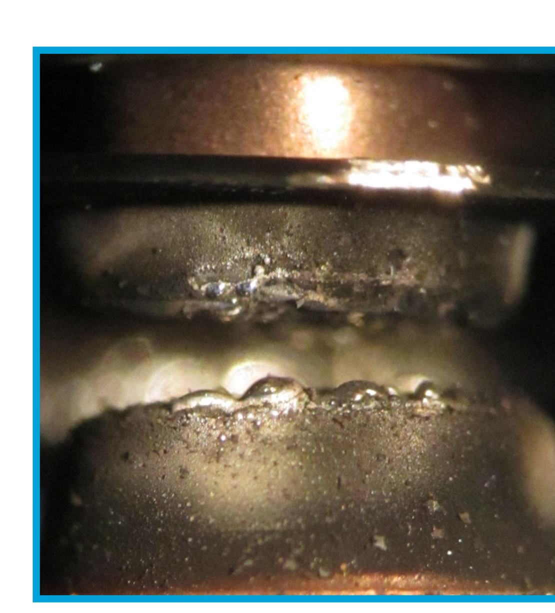

Figure IV: Uncontrolled μ-arc welding in the Wet PCC yields a destroyed contact at 100K cycles

References:
1. R. Henke and R.P. Thorbus, "Rethinking Contact Current Arcing," Arc Suppression Technologies publication, 2015
2. R. Henke and R.P. Thorbus, "The Dry Power Contact Cycle," Arc Suppression Technologies publication, January 2021