

The Arc Lifecycle

An "arc" is a man-made "arc-discharge phenomena" in which burning plasma is maintained by a permanent AC or DC power source. Arcs are "contact arcs" when connecting or disconnecting power (intentionally or unintentionally). Every arc follows the same life-cycle of: 1. Initiation, 2. Plasma, and 3. Dissipation; and occasionally 4. Re-Initiation (Table I, ref. 1). (Note that "sparks" and "arcs" are NOT the same ... sparks, whether a small electrostatic shock or a bolt of lightning, are initiated by field emissions and are supported by a transient power supply.)

What Is The "Arc Species Zoo"?

There are a vast number of different arc "animal names" due to arcs being named as they were observed across different applications and industries during the industrialization of electricity. This is similar, however, to the names of "Puma," "Mountain Lion," and "Cougar" being given to the same big cat species depending on where and by whom it was first encountered. Further complicating the understanding of arcs is the frequent association with "sparks," which do not occur within the power contact cycle!

After 10 years of industrial research, sifting through the "clutter and confusion" of the "zoo" of innumerable arc "names," we now understand that there are only three basic "species". We differentiate these "arc species" by their respective arc initiation (Table II).

1. Initiation "Birth"
There are two arc initiation mechanisms: <ul style="list-style-type: none"> • Thermionic-emission-initiated-arc — "T-Arc" • Field-emission-initiated-arc — "F-Arc"
2. Plasma "Life"
There are two types of power that maintain an arc: <ul style="list-style-type: none"> • Alternating Current (AC) • Direct Current (DC)
3. Dissipation "Death"
Dispersion of residual ionization, heat and debris
4. Possible Re-Initiation "Afterlife"
Residual ionization, heat and debris may yield: <ul style="list-style-type: none"> • Favorable conditions within gap for re-initiation • Plasma reigniting and burning again (F-Arc only)

Table I (above): The Arc Life-Cycle

"Arc Species"	T-Arc Species	F-Arc Species	T-Arc/F-Arc Hybrid
Arc Initiation Mechanism	Current flowing + opening or closed contact + Joule heating + thermionic emission + plasma = T-Arc	Voltage present + closing or open contact + dielectric breakdown + field emission + plasma = F-Arc	T-Arc followed a series of re-initiated F-Arcs — or — F-Arc followed a series of re-initiated F-Arcs
Examples of "Arc Names" (In alphabetical order; by no means a complete list)	Bounce arc, Break arc, Break bounce arc, Breaking arc, Cleaning arc, Clearing arc, Drawn arc, Fault arc, Floating arc, Make bounce arc, Metallic arc, Opening arc, Short arc, etc.	Chopping arc, Closing arc, Fault arc, Flashover arc, Gaseous arc, Make arc, Making arc, Reinitiated arc, Secondary arc, Vacuum arc, etc.	Circular arc, Contact arc, Continuing arc, Commutator arc, Hissing arc, Inductive arc, Internal arc, Interrupted arc, Long arc, Low pressure arc, Ongoing arc, Showering arc, Standing arc, Switching arc, Transient arc, Welding arc, etc.

Table II (above): "Arc Species" Definitions by Arc Initiation Mechanism(s)

Arcs in the Contact Cycle

Arcs are either **T-Arcs** or **F-Arcs** between two electrodes and **are supported by a continuous supply of power** (Table III, ref. 2).

Why is this important? Because the large number of "animal names" in the Arc Species Zoo (often combined with a conflation of arcs and sparks; which are NOT the same) have resulted in confusion.

This confusion has led engineers, designers, and technicians to employ inadequate or inappropriate arc suppression counter-mechanisms in an attempt to suppress contact arcing. For example, "snubbers" do not suppress the various arcs that occur during normal relay or contactor operation ("snubbers" are for "sparks").

We hope that our findings, which are based on 10 years of industrial research, can help industry better understand the problems associated with arcing ... and how to implement better solutions to suppress arcing.

Contact Cycle State	Equivalent Lumped Element Circuit Diagram	Notes	Arc Initiation Mechanism	Arc Name Example(s)
I. OPEN		A fault can occur if the voltage across the opened contact exceeds the contact's dielectric isolation voltage rating.	F-Arc	Flashover arc Fault arc
II. MAKE		The closing contact will experience a normal dielectric breakdown before making contact.	F-Arc	Make arc
			T-Arc	Bounce arc
			Hybrid	Inductive arc
III. CLOSED		A fault can occur if the current through the closed contact exceeds the contact's short circuit current rating.	T-Arc	Floating arc Fault arc
IV. BREAK		The opening contact will experience a normal Joule heating (I²R effect) before breaking contact.	T-Arc	Drawn arc
			F-Arc	Re-initiated arc
			Hybrid	Continuing Arc

Table III (above): Arc initiation mechanisms within the contact cycle.

References:

1. M. Atalla, Mechanisms of the initiation of the short Arc, 1954
2. R. Holm, Electric Contacts Handbook, Springer Verlag, 1958