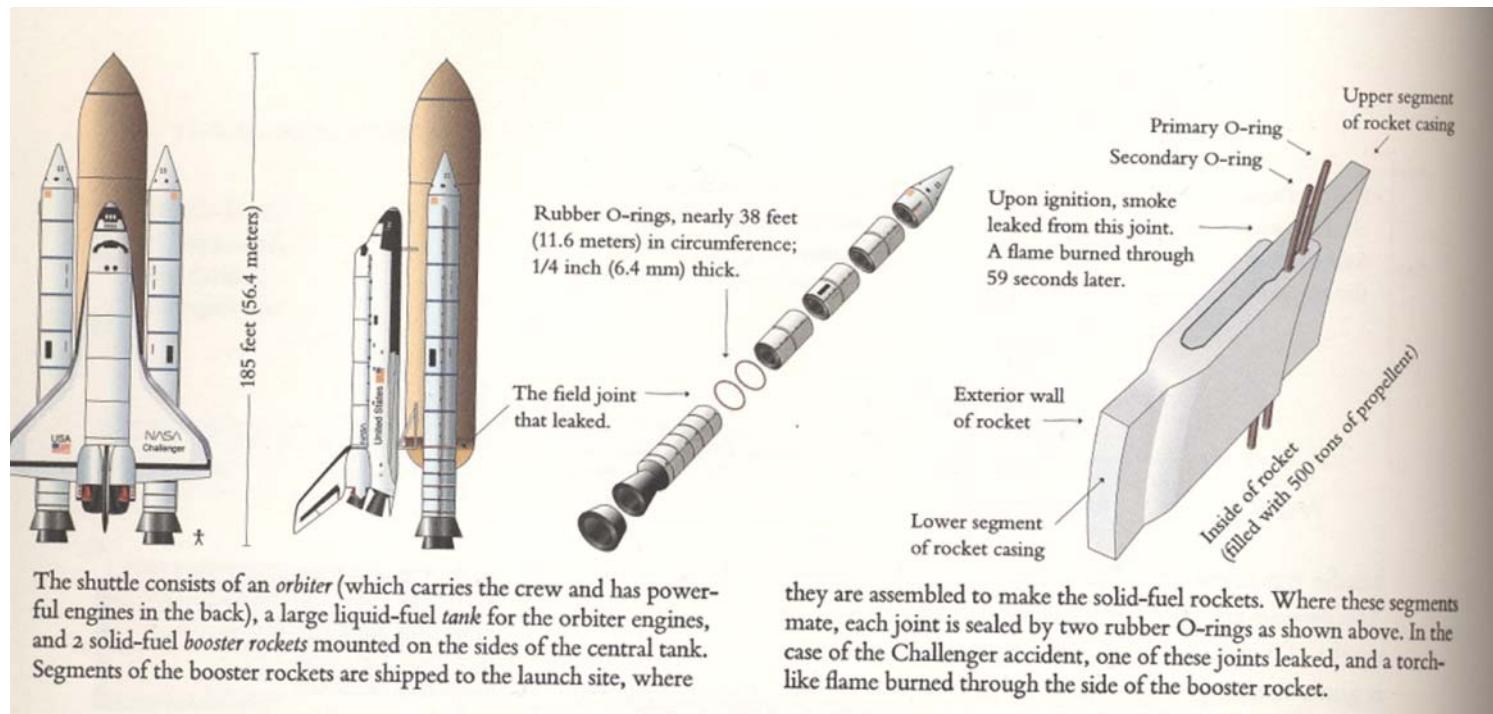
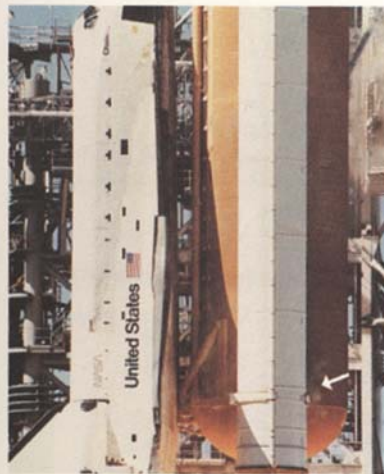


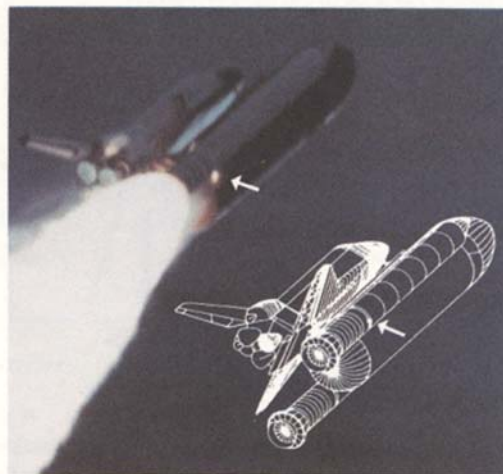
Challenger Visualization







Less than 1 second after ignition, a puff of smoke appeared at the aft joint of the right booster, indicating that the O-rings burned through and failed to seal. At this point, all was lost.



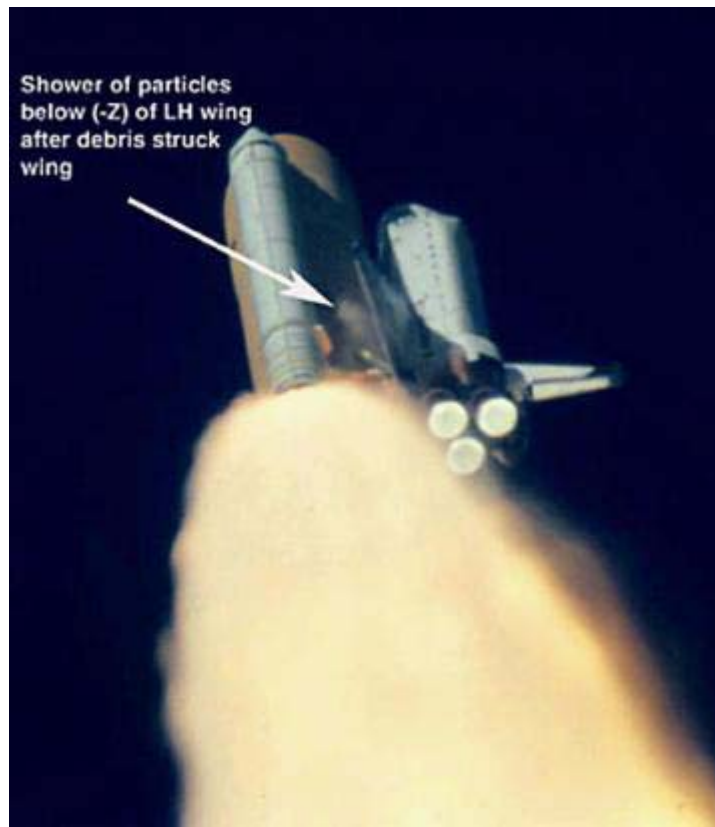
On the launch pad, the leak lasted only about 2 seconds and then apparently was plugged by putty and insulation as the shuttle rose, flying through rather strong cross-winds. Then 58.788 seconds after ignition, when the Challenger was 6 miles up, a flicker of flame emerged from the leaky joint. Within seconds, the flame grew and engulfed the fuel tank (containing liquid hydrogen and liquid oxygen). That tank ruptured and exploded, destroying the shuttle.



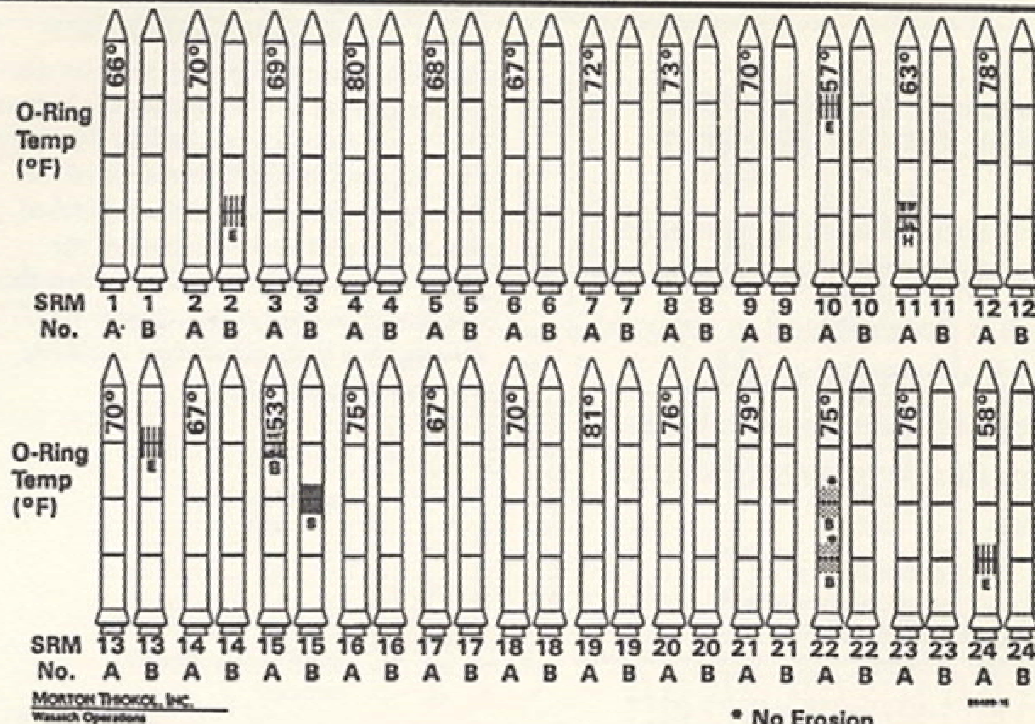


As the shuttle exploded and broke up at approximately 73 seconds after launch, the two booster rockets crisscrossed and continued flying wildly. The right booster, identifiable by its failure plume, is now to the left of its non-defective counterpart.





History of O-Ring Damage in Field Joints (Cont)



INFORMATION ON THIS PAGE WAS PREPARED TO SUPPORT AN ORAL PRESENTATION
AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION

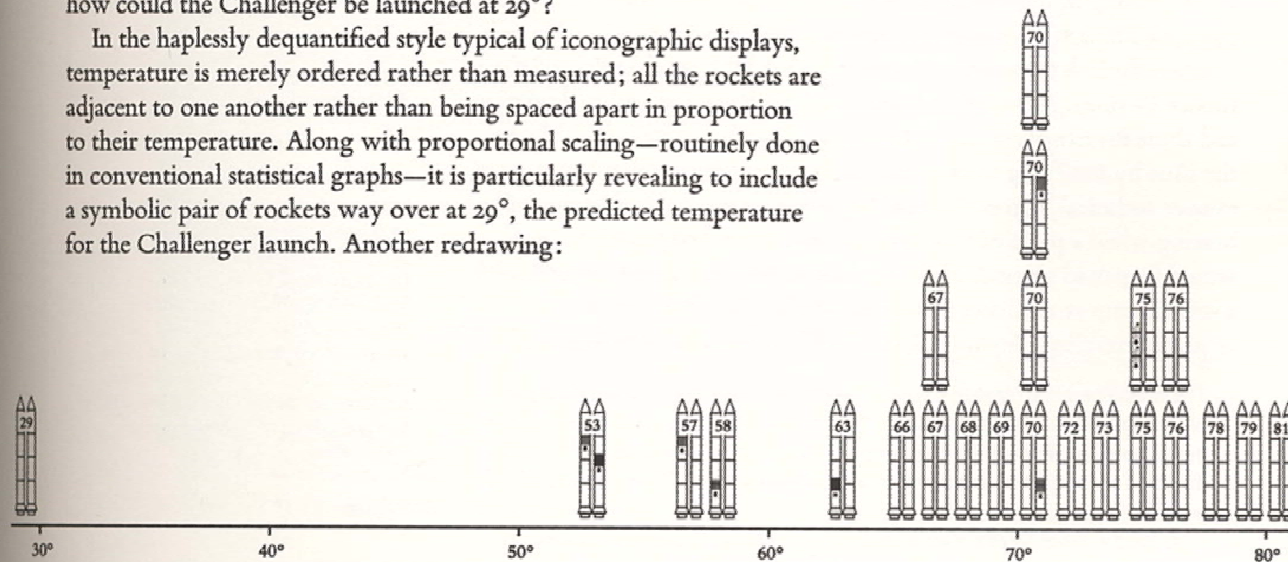


Flight	Date	Temperature °F	Erosion incidents	Blow-by incidents	Damage index	Comments
51-C	01.24.85	53°	3	2	11	Most erosion any flight; blow-by; back-up rings heated.
41-B	02.03.84	57°	1		4	Deep, extensive erosion.
61-C	01.12.86	58°	1		4	O-ring erosion on launch two weeks before Challenger.
41-C	04.06.84	63°	1		2	O-rings showed signs of heating, but no damage.
1	04.12.81	66°			0	Coollest (66°) launch without O-ring problems.
6	04.04.83	67°			0	
51-A	11.08.84	67°			0	
51-D	04.12.85	67°			0	
5	11.11.82	68°			0	
3	03.22.82	69°			0	
2	11.12.81	70°	1		4	Extent of erosion not fully known.
9	11.28.83	70°			0	
41-D	08.30.84	70°	1		4	
51-G	06.17.85	70°			0	
7	06.18.83	72°			0	
8	08.30.83	73°			0	
51-B	04.29.85	75°			0	
61-A	10.30.85	75°		2	4	No erosion. Soot found behind two primary O-rings.
51-I	08.27.85	76°			0	
61-B	11.26.85	76°			0	
41-G	10.05.84	78°			0	
51-J	10.03.85	79°			0	
4	06.27.82	80°			?	O-ring condition unknown; rocket casing lost at sea.
51-F	07.29.85	81°			0	



Information displays should serve the analytic purpose at hand; if the substantive matter is a possible cause-effect relationship, then graphs should organize data so as to illuminate such a link. Not a complicated idea, but a profound one. Thus the little rockets must be *placed in order by temperature, the possible cause*. Above, the rockets are so ordered by temperature. This clearly shows the serious risks of a cold launch, for most O-ring damage occurs at cooler temperatures. Given this evidence, how could the Challenger be launched at 29°?

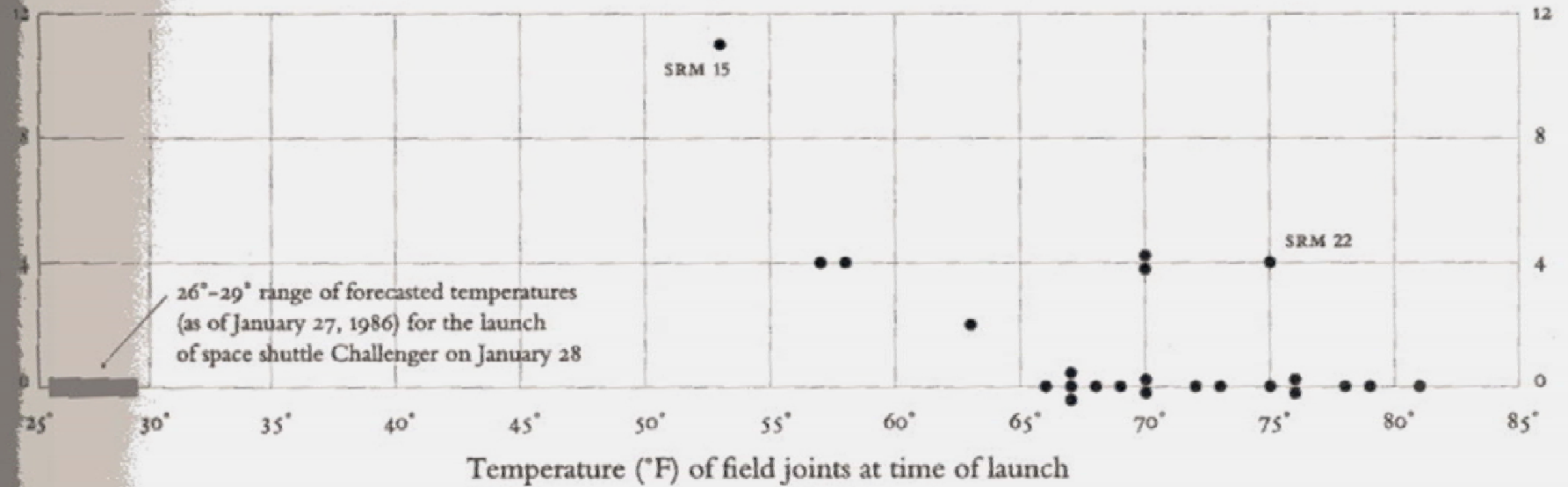
In the haplessly dequantified style typical of iconographic displays, temperature is merely ordered rather than measured; all the rockets are adjacent to one another rather than being spaced apart in proportion to their temperature. Along with proportional scaling—routinely done in conventional statistical graphs—it is particularly revealing to include a symbolic pair of rockets way over at 29°, the predicted temperature for the Challenger launch. Another redrawing:



Even after repairs, the pictorial approach with cute little rockets remains ludicrous and corrupt. The excessively original artwork just plays around with the information. It is best to forget about designs involving such icons and symbols—in this case and, for that matter, in nearly all other cases. These data require only a simple scatterplot or an ordered table to reveal the deadly relationship.



O-ring damage
index, each launch





Richard P. Feynman – Biography



Richard P. Feynman was born in New York City on the 11th May 1918. He studied at the [Massachusetts Institute of Technology](#) where he obtained his B.Sc. in 1939 and at [Princeton University](#) where he obtained his Ph.D. in 1942. He was Research Assistant at Princeton (1940-1941), Professor of Theoretical Physics at [Cornell University](#) (1945-1950), Visiting Professor and thereafter appointed Professor of Theoretical Physics at the [California Institute of Technology](#)

(1950-1959). At present he is Richard Chace Tolman Professor of Theoretical Physics at the California Institute of Technology.

Professor Feynman is a member of the [American Physical Society](#), the American Association for the Advancement of Science; the [National Academy of Science](#); in 1965 he was elected a foreign member of the Royal Society, London (Great Britain).

He holds the following awards: Albert Einstein Award (1954, Princeton); Einstein Award (Albert Einstein Award College of Medicine); Lawrence Award (1962).

Richard Feynman is married to Gweneth Howarth, they have a son, Carl Richard (born 22nd April 1961), and a daughter Michelle Catherine (born 13th August 1968).

From [Nobel Lectures](#), Physics 1963-1970.

Richard Feynman died in 1988.





