MMC Capacitor Power Handling Calculations

Capacitor Energy per Bang

$E_{CAP} = 0.5\ C_o\ (V_P / N_{LINE})^2$

Where:
E_{CAP} = Energy Stored in Single Capacitor per Bang (Joules)
C_o = Capacitance of a Single Capacitor (Farads)
V_P = Gap Firing Voltage (Volts)
N_{LINE} = Number of Capacitors per String

Internal Resistance of a Single Capacitor

$R_{CAP} = TANd / (2\ p\ C_o\ F)$

Where:
R_{CAP} = Internal Real Resistance of a Single Capacitor (Ohms)
TANd = Dissipation Factor
C_o = Capacitance of a Single Capacitor (Farads)
F = Fundamental Frequency of Primary Circuit (Hz)

F (kHz)	TANd
10	0.0004
50	0.0008
100	0.0010
200	0.0016
300	0.0024
400	0.0040

Power Dissipation per Small Capacitor

$W_o = K_{SYNC}\ BPS\ E_{CAP}\ R_{CAP} / (R_{CAP} + R_{PRI})$

Where:
W_o = Power Dissipation per Small Capacitor (Watts)
K_{SYNC} = 1 for Synchronous Gap or 0.5 for Non-Synchronous Gap
BPS = Bangs per Second
E_{CAP} = Energy Stored in Single Capacitor per Bang (Joules)
R_{CAP} = Internal Real Resistance of a Single Capacitor (Ohms)
R_{PRI} = Primary Circuit Equivalent Resistance (~3 Ohms)

Temperature Rise of Small Capacitor

$T_o = W_o\ K_o$

Where:
T_o = Temperature Rise of Small Capacitor (° C)
W_o = Power Dissipation per Small Capacitor (Watts)
K_o = Small Capacitor Thermal Dissipation Factor (° C / Watt)

Lead Spacing (mm)	K_o
5	250
7.5	167
10	133
15	83
22.5	67
27.5	40
37.5	33

Reliability

T_o (° C)	Reliability
0 - 5	Very Good
5 - 10	Good
10 -15	?
> 15	Bad

Life Expectancy

$L_{LIFE} = 10^6 ((V_{ACcap} N_{LINE}) / V_{AC})^{15}$

Where:
L_{LIFE} = Life Expectancy of Capacitor (Hours)
V_{ACcap} = AC Voltage Rating of a Single Capacitor (VAC)
N_{LINE} = Number of Capacitors per String
V_{AC} = RMS Voltage of Primary Charging Transformer (VAC)

Example:

Total Primary Capacitance = 28nF
Fundamental Frequency = 100 kHz
Firing Voltage = 21000 Volts (15000 VAC)
BPS = 120
Gap = Non-Synchronous
Primary Capacitor = 7 strings of 14 x 56nF small caps whose lead spacing is 27.5 mm and the AC voltage rating is 630 VAC.

How reliable would this be and how long should it last?

$E_{CAP} = 0.5 C_o (V_P / N_{LINE})^2$
$E_{CAP} = (0.5) (56 \times 10^{-9}) (21000 / 14)^2$
$E_{CAP} = 0.063$ Joule

$R_{CAP} = TANd / (2 p C_o F)$
$R_{CAP} = 0.0010 / (2 p (56 \times 10^{-9}) 100000)$
$R_{CAP} = 0.02842$ Ohm

$W_o = K_{SYNC} BPS E_{CAP} R_{CAP} / (R_{CAP} + R_{PRI})$
$W_o = (0.5) (120) (0.063) (0.02842) / (0.02842 + 3)$
$W_o = 0.0355$ Watt

$T_o = K_o W_o$
$T_o = 40 \times 0.0355$
$T_o = 1.42$ ° C

$L_{LIFE} = 10^6 ((V_{ACcap} N_{LINE}) / V_{AC})^{15}$
$L_{LIFE} = 10^6 ((630 \times 14) / 15000)^{15}$
$L_{LIFE} = 347$ Hours

The reliability should be "Very Good".

The Life Expectancy is 347 Hours.