PEH 300 85°C Snap-In Electrolytic Capacitor

- Long Life Grade
- Low ESR and ESL
- PCB Mounting
- High ripple current

Application

Typical applications for PEH 300 would be electric drives, welding equipment, UPS and other power electronic applications where high current ratings and compact size are important.

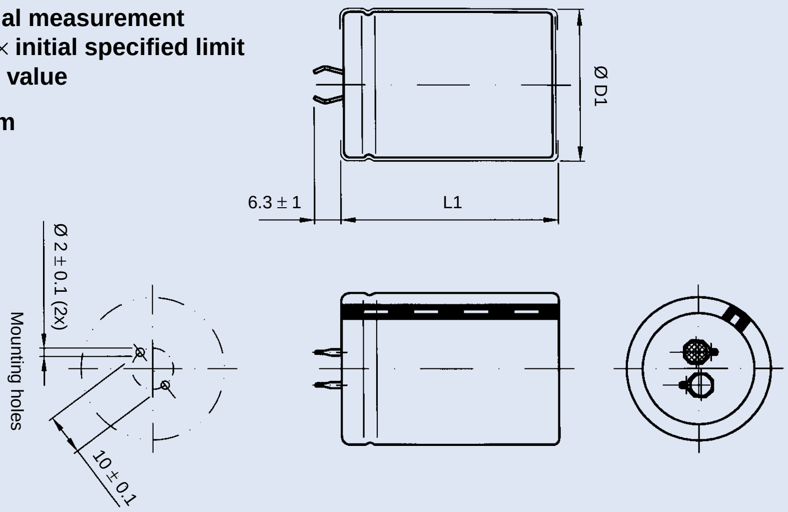
Basic design

PEH 300 is a Long Life electrolytic capacitor designed to offer high ripple current capability and low mounting cost. The low ESR is a result of very low resistive paper/electrolyte system.

The low ESR together with the TDC thermal concept gives the PEH 300 a very high ripple current capability. The robust mechanical construction gives a high-class vibration resistance.

Specification

Standards	**IEC 384-4 Long Life Grade 40/085/56, in accordance with CECC 30 301-811 (forthcoming standard)**
Capacitance range	**150–1000 µF**
Capacitance tolerance	**–20 to +20%**
Rated voltage	**200–450 VDC**
Temperature range	**–40 to +85°C**
Leakage current, I_{RL} (µA)	**0.006 (µA) × C_R (µF) × U_R (V) + 4 (µA) (20°C, 5 min)**
Shelf life	**4 years (at 0 Volt and +40°C)**
Life validation test	**5000 hours, +85°C $10 \leq U_R \leq 160$ VDC $\Delta C/C \leq \pm 15\%$ $U_R > 160$ VDC $\Delta C/C \leq \pm 10\%$ from initial measurement ESR ≤ 3 × initial specified limit $I_L \leq$ rated value**
Diameter range	**30–35 mm**



Dimensions table PEH 300 (mm)

D × L	Case code	D1 ±0.5	L1 ±1.0	Weight approx (g)
30 × 40	R	30.5	41	35
30 × 45	S	30.5	46	40
30 × 50	T	30.5	51	45
35 × 40	X	35.5	41	45
35 × 45	Y	35.5	46	55
35 × 50	Z	35.5	51	65

Article table PEH 300 85°C

U_R	C_R µF	D × L mm	Case code	I_{RAC}* 85°C 100 Hz A	I_{RAC}* 40°C 20 kHz A	ESR* 20°C 100 Hz mΩ	ESR* 20°C 100 kHz mΩ	Article code 1st block
200 VDC	560	30 × 40	R	2.0	6.0	240	130	PEH 300RR3560M
	680	30 × 45	S	2.3	6.7	200	110	PEH 300RS3680M
	820	30 × 50	T	2.6	7.5	160	93	PEH 300RT3820M
	820	35 × 40	X	2.6	7.5	170	95	PEH 300RX3820M
	1000	35 × 45	Y	3.0	8.4	140	78	PEH 300RY4100M
	1200	35 × 50	Z	3.3	9.4	110	66	PEH 300RZ4120M
250 VDC	390	30 × 40	R	1.8	5.8	280	140	PEH 300SR3390M
	470	30 × 45	S	2.0	6.5	230	120	PEH 300SS3470M
	560	30 × 50	T	2.3	7.2	200	100	PEH 300ST3560M
	560	35 × 40	X	2.3	7.2	200	100	PEH 300SX3560M
	680	35 × 45	Y	2.6	8.1	160	86	PEH 300SY3680M
	820	35 × 50	Z	2.9	9.0	140	72	PEH 300SZ3820M
350 VDC	270	30 × 40	R	1.7	5.9	300	140	PEH 300UR3270M
	330	30 × 45	S	1.9	6.7	240	110	PEH 300US3330M
	390	30 × 50	T	2.2	7.4	210	95	PEH 300UT3390M
	390	35 × 40	X	2.2	7.4	210	98	PEH 300UX3390M
	470	35 × 45	Y	2.5	8.3	170	81	PEH 300UY3470M
	560	35 × 50	Z	2.7	9.2	150	69	PEH 300UZ3560M
385 VDC	220	30 × 40	R	1.6	5.3	340	160	PEH 300XR3220M
	270	30 × 45	S	1.8	6.0	280	130	PEH 300XS3270M
	330	30 × 50	T	2.0	6.6	230	110	PEH 300XT3330M
	330	35 × 40	X	2.1	7.3	220	100	PEH 300XX3330M
	390	35 × 45	Y	2.3	8.1	190	86	PEH 300XY3390M
	470	35 × 50	Z	2.6	9.0	160	72	PEH 300XZ3470M
400 VDC	220	30 × 40	R	1.7	5.9	310	140	PEH 300VR3220M
	270	30 × 45	S	1.9	6.7	250	110	PEH 300VS3270M
	330	30 × 50	T	2.1	7.6	210	91	PEH 300VT3330M
	330	35 × 40	X	2.2	7.5	210	93	PEH 300VX3330M
	390	35 × 45	Y	2.4	8.4	180	79	PEH 300VY3390M
	470	35 × 50	Z	2.7	9.3	150	66	PEH 300VZ3470M
420 VDC	180	30 × 40	R	1.6	5.8	340	140	PEH 300OR3180M
	220	30 × 45	S	1.8	6.6	280	120	PEH 300OS3220M
	270	30 × 50	T	2.0	7.4	230	96	PEH 300OT3270M
	270	35 × 40	X	2.1	7.4	230	98	PEH 300OX3270M
	330	35 × 45	Y	2.3	8.3	190	81	PEH 300OY3330M
	390	35 × 50	Z	2.6	9.1	160	69	PEH 300OZ3390M
450 VDC	150	30 × 40	R	1.5	5.2	390	170	PEH 300YR3150M
	180	30 × 45	S	1.6	5.8	320	140	PEH 300YS3180M
	220	30 × 50	T	1.8	6.4	270	110	PEH 300YT3220M
	220	35 × 40	X	1.9	7.0	260	110	PEH 300YX3220M
	270	35 × 45	Y	2.2	7.9	210	89	PEH 300YY3270M
	330	35 × 50	Z	2.5	8.9	170	74	PEH 300YZ3330M

* Maximum values

PEH 330 105°C Snap-In Electrolytic Capacitor

- **Long Life Grade**
- **Low ESR and ESL**
- **PCB Mounting**
- **High ripple current**

Application

Typical applications for PEH 330 would be electric drives, welding equipment, UPS and other power electronic applications where high current ratings and compact size are important.

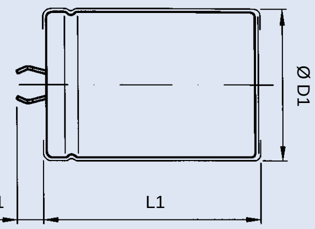
Basic design

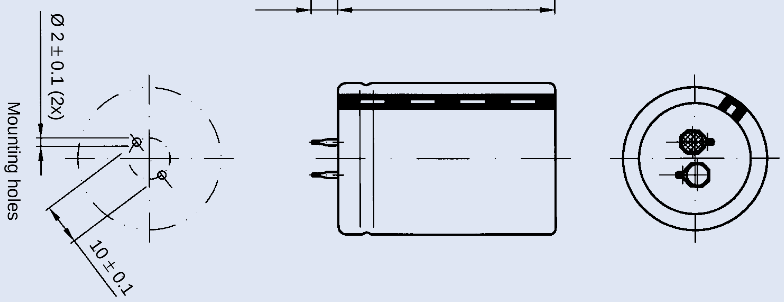
PEH 330 is a Long Life electrolytic capacitor designed to offer high ripple current capability and low mounting cost. The low ESR is a result of very low resistive paper/electrolyte system.

The low ESR together with the TDC thermal concept gives the PEH 330 a very high ripple current capability. The robust mechanical construction gives a high-class vibration resistance.

Specification

Standards	**IEC 384-4 Long Life Grade 40/105/56, in accordance with CECC 30 301-809**
Capacitance range	**150–12000 μF**
Capacitance tolerance	**–20 to +20%**
Rated voltage	**40–400 VDC**
Temperature range	**–40 to +105°C**
Leakage current, I_{RL} (μA)	**0.006 (μA) × C_R (μF) × U_R (V) + 4 (μA) (20°C, 5 min)**
Shelf life	**4 years (at 0 Volt and +40°C)**
Life validation test	**2000 hours, +105°C** **$10 \leq U_R \leq 160$ VDC $\Delta C/C \leq \pm 15\%$** **$U_R > 160$ VDC $\Delta C/C \leq \pm 10\%$** **from initial measurement** **ESR ≤ 3 × initial specified limit** **$I_L \leq$ rated value**
Diameter range	**30–35 mm**





Dimensions table PEH 330 (mm)

D × L	Case code	D1 ±0.5	L1 ±1.0	Weight approx (g)
30 × 40	R	30.5	41	35
30 × 45	S	30.5	46	40
30 × 50	T	30.5	51	45
35 × 40	X	35.5	41	45
35 × 45	Y	35.5	46	55
35 × 50	Z	35.5	51	65

Article table PEH 330 105°C

U_R	C_R µF	D × L mm	Case code	I_{RAC}* 105°C 100 Hz A	I_{RAC}* 40°C 20 kHz A	ESR* 20°C 100 Hz mΩ	ESR* 20°C 100 kHz mΩ	Article code 1st block
40 VDC	5600	30 × 40	R	2.6	9.8	47	37	PEH 330KR4560M
	6800	30 × 45	S	2.9	10.8	39	32	PEH 330KS4680M
	8200	30 × 50	T	3.2	11.8	34	27	PEH 330KT4820M
	8200	35 × 40	X	3.8	14.3	29	23	PEH 330KX4820M
	10000	35 × 45	Y	4.2	15.9	24	19	PEH 330KY5100M
	12000	35 × 50	Z	4.7	17.4	21	16	PEH 330KZ5120M
63 VDC	3300	30 × 40	R	2.4	9.6	49	34	PEH 330MR4330M
	3900	30 × 45	S	2.6	10.7	42	29	PEH 330MS4390M
	4700	30 × 50	T	2.9	11.5	36	25	PEH 330MT4470M
	4700	35 × 40	X	3.4	14.8	30	20	PEH 330MX4470M
	5600	35 × 45	Y	3.8	16.3	26	17	PEH 330MY4560M
	6800	35 × 50	Z	4.2	17.8	22	14	PEH 330MZ4680M
100 VDC	1000	30 × 40	R	1.6	7.6	120	72	PEH 330PR4100M
	1200	30 × 45	S	1.8	8.5	97	61	PEH 330PS4120M
	1500	30 × 50	T	2.1	9.5	79	50	PEH 330PT4150M
	1500	35 × 40	X	2.2	10.8	74	45	PEH 330PX4150M
	1800	35 × 45	Y	2.5	12.0	62	38	PEH 330PY4180M
	2200	35 × 50	Z	2.8	13.4	51	32	PEH 330PZ4220M
200 VDC	390	30 × 40	R	0.91	4.7	350	200	PEH 330RR3390M
	470	30 × 45	S	1.0	5.3	290	170	PEH 330RS3470M
	560	30 × 50	T	1.1	5.9	240	140	PEH 330RT3560M
	560	35 × 40	X	1.2	6.3	240	130	PEH 330RX3560M
	680	35 × 45	Y	1.3	7.1	200	110	PEH 330RY3680M
	820	35 × 50	Z	1.5	7.9	160	93	PEH 330RZ3820M
250 VDC	270	30 × 40	R	0.81	4.6	410	210	PEH 330SR3270M
	330	30 × 45	S	0.91	5.1	340	180	PEH 330SS3330M
	390	30 × 50	T	1.0	5.7	290	150	PEH 330ST3390M
	390	35 × 40	X	1.1	6.1	280	140	PEH 330SX3390M
	470	35 × 45	Y	1.2	6.8	230	120	PEH 330SY3470M
	560	35 × 50	Z	1.3	7.5	200	100	PEH 330SZ3560M
350 VDC	180	30 × 40	R	0.78	4.9	410	190	PEH 330UR3180M
	220	30 × 45	S	0.88	5.5	340	150	PEH 330US3220M
	270	30 × 50	T	1.0	6.2	280	130	PEH 330UT3270M
	270	35 × 40	X	1.0	6.6	270	120	PEH 330UX3270M
	330	35 × 45	Y	1.2	7.5	220	100	PEH 330UY3330M
	390	35 × 50	Z	1.3	8.3	190	85	PEH 330UZ3390M
385 VDC	180	30 × 40	R	0.81	5.1	390	170	PEH 330XR3180M
	220	30 × 45	S	0.91	5.7	320	140	PEH 330XS3220M
	270	30 × 50	T	1.0	6.4	260	120	PEH 330XT3270M
	270	35 × 40	X	1.1	6.9	250	110	PEH 330XX3270M
	330	35 × 45	Y	1.2	7.8	210	92	PEH 330XY3330M
	390	35 × 50	Z	1.4	8.6	180	78	PEH 330XZ3390M
400 VDC	150	30 × 40	R	0.77	5.0	410	180	PEH 330VR3150M
	180	30 × 45	S	0.86	5.6	350	150	PEH 330VS3180M
	220	30 × 50	T	0.97	6.2	280	120	PEH 330VT3220M
	220	35 × 40	X	1.0	6.7	280	120	PEH 330VX3220M
	270	35 × 45	Y	1.2	7.6	230	97	PEH 330VY3270M
	330	35 × 50	Z	1.3	8.5	190	80	PEH 330VZ3330M

* Maximum values

Operational data

The life of an electrolytic capacitor is mainly determined by the temperature in the hottest part of the winding, the so-called Hot Spot temperature (T_h). This temperature is found by taking the ambient temperature and adding the capacitor temperature rise due to the applied ripple current. The thermal resistance is determined by the cooling conditions and the thermal design of the capacitor. The hot-spot temperature is calculated as:

$T_h = T_a + R_{th} \times P_{LOSS}$

where

T_h = Hot Spot temperature,

T_a = ambient temperature,

R_{th} = thermal resistance

P_{LOSS} = $I_{RMS}^2 \times ESR$ = powerloss

The hot-spot temperature and the applied voltage gives the expected operational life time.

Mechanical data

The capacitor may be mounted in any position. The PEH 300 and PEH 330 are supplied with PVC insulation sleeve, thickness 0.3 mm. Voltage proof of the insulation sleeve = 2.5 kVDC (1 min).

The minus pole is marked on the case surface.

Ordering information

1st block (pos 1–13)

P	E	H	3	0	0	K	U	5	6	8	0	M
1	2	3	4	5	6	7	8	9	10	11	12	13

Pos. 13: Capacitance tolerance M = –20 to +20%

Quantities and weights

CASE CODE	R	S	T	X	Y	Z
Weight approx (g)	35	40	45	45	55	65
Stand. box quantity	56	56	56	42	42	42

Typical data PEH 300 and PEH 330

Fig. 1

C_T = C(f=100 Hz, T_h) / C(f=100 Hz, T_h = 20°C) vs T_h

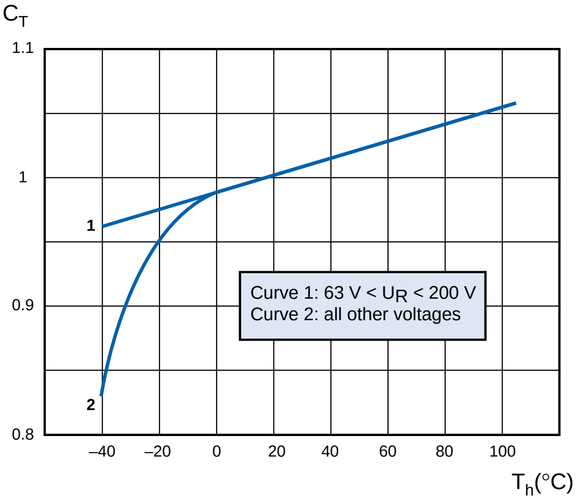


Fig. 4

k_f = ESR(f, T_h = 20°C) / ESR(f = 100 Hz, T_h = 20°C) vs f

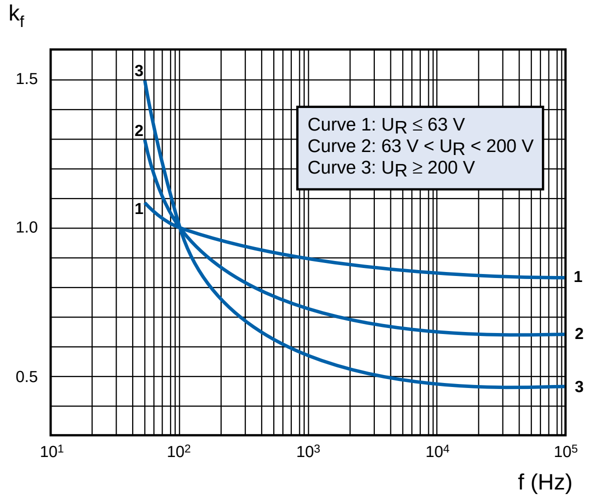


Fig. 2

k_T = ESR(f, T_h) / ESR(f, T_h = 20°C) vs T_h, U_R < 200 V

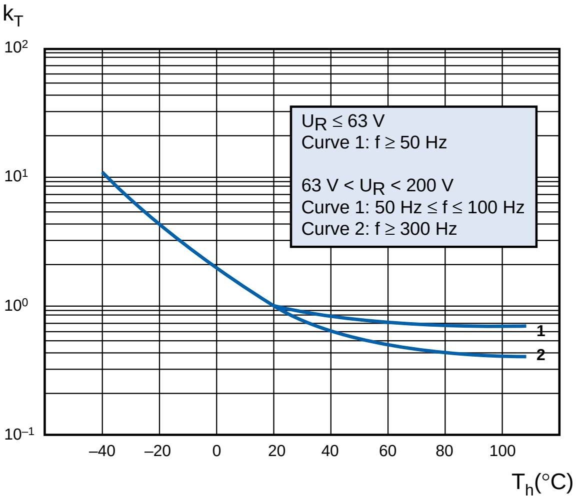


Fig. 5

k_T = ESR(f, T_h) / ESR(f, T_h = 20°C) vs T_h, U_R ≥ 200 V

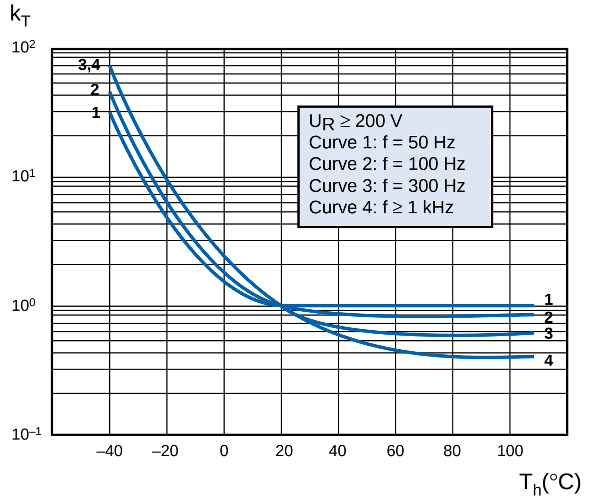


Fig. 3

R_{th} vs v_{air}

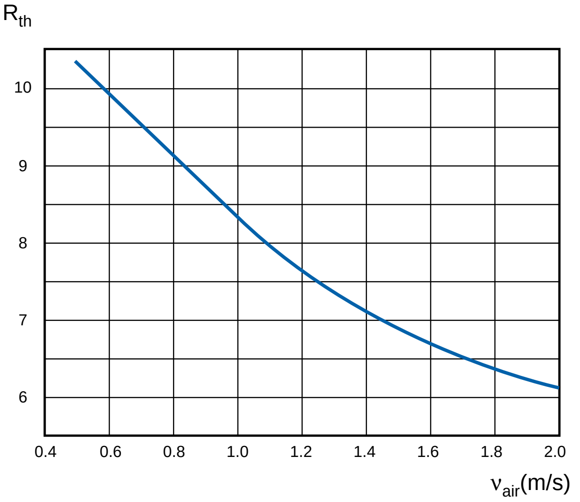
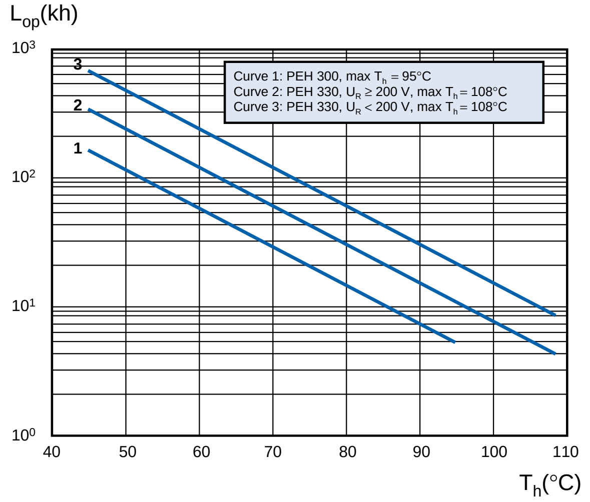


Fig. 6

L_{op} vs T_h



PEH 300 Calculation example

Snap-in capacitors are typically used in converters, where they are exposed to both a low-frequency rectifier-ripple current (e.g. f_{lf} = 100 Hz or 300 Hz) and a high-frequency switch current (f_{hf} = 10 kHz to 100 kHz). The capacitor's ambient temperature, i.e. the temperature inside the module, is often between 40 °C and 60 °C. No forced air cooling is normally applied specifically to the capacitors. However, a practical air velocity value of around 0.5 m/s can be assumed in many cases due to leakage from forced air cooling of active devices and temperature gradient induced air streams inside the module.

Example:
Calculate the minimum operational lifetime for a PEH300VY3390M snap-in capacitor used in a converter under the following working conditions:

- Rectifier-ripple current $\mathbf{I_{lf} = 3.5}$ **A** at frequency $\mathbf{f_{lf} = 300}$ **Hz**
- Switch current $\mathbf{I_{hf} = 2.0}$ **A** at frequency $\mathbf{f_{hf} = 30}$ **kHz**
- Total (AC+DC) voltage $\mathbf{U_{appl} = 350}$ **V**
- Ambient temperature $\mathbf{T_a = 60}$ **°C**
- No forced air cooling is applied

The typical performance plots on page 48 are to be used, as are the following capacitor-related formulae:

[1] $\mathbf{ESR(f_i,T_h) = ESR(f = 100\,Hz, T_h = 20\,°C) \times k_f(f_i, T_h = 20°C) \times k_T(f_i,T_h)}$

[2] $\mathbf{P_{tot} = \sum_i ESR(f_i,T_h) \times I^2(f_i)}$

[3] $\mathbf{\Delta T = P_{tot} \times R_{th}(\nu_{air})}$

[4] $\mathbf{T_h = T_a + \Delta T}$

[5] $\mathbf{k_U = \left(\frac{U_{appl}}{U_R}\right)^5 = q_U^5}$

[6] $\mathbf{L_{op}(T_h, U_{appl}) = L_{op}(T_h, U_R) / k_U}$

Solution:
Starting with the low-frequency rectifier-ripple current, the article table specifies **maximum ESR** (T_h = 20°C, f = 100 Hz). For PEH 300VY3390M it is given as ESR(T_h = 20°C, f = 100 Hz) = 180 mΩ.

The **ESR frequency correction factor $\mathbf{k_f}$** is given by Figure 4. At f_{lf} = 300 Hz it is found that $k_f \approx 0.7$.

The **ESR temperature correction factor $\mathbf{k_T}$** is given by Figure 5. Along the x-axis in this figure is given the **capacitor internal 'hot-spot' temperature $\mathbf{T_h}$**. Approximate T_h at first by $T_h \approx T_a$. At f_{lf} = 300 Hz and $T_h \approx T_a$ = 60 °C it is found that $k_T \approx 0.6$.

The low-frequency **application-specific ESR** can now be calculated [1]: ESR_{lf} = ESR(T_h = 20°C, f = 100 Hz) × $k_f \times k_T \approx 180 \times 0.7 \times 0.6$ mΩ ≈ 76 mΩ. Note that ESR under the above working conditions is only around 40% of the value specified in the article table.

The high-frequency application-specific ESR is calculated in a similar manner. The article table specifies ESR (T_h = 20°C, f = 100 kHz) = 79 mΩ. From Figure 4 it is seen that ESR do not vary much between 30 kHz and 100 kHz, meaning we can use the ESR-value from the article table also at f_{hf} = 30 kHz. Figure 5 gives $k_T \approx 0.4$. ESR_{hf} is now calculated as ESR_{hf} = ESR(T_h = 20°C, f = 100 kHz) $\times k_T \approx 79 \times 0.4$ mΩ ≈ 32 mΩ. Also this value is around 40% of the article table value.

The **total power $\mathbf{P_{tot}}$ dissipated in the capacitor** is the sum of the low- and high-frequency contributions [2]: $P_{tot} = ESR_{lf} \times I_{lf}^2 + ESR_{hf} \times I_{hf}^2 \approx 76 \times 3.5^2 + 32 \times 2.0^2$ mW ≈ 1.1 W.

The **thermal resistance $\mathbf{R_{th}}$** is given by Figure 3. As no forced air cooling is applied an air velocity of ν_{air} = 0.5 m/s is assumed (see above). It is found that $R_{th} \approx 10$°C/W.

The temperature rise ΔT inside the capacitor due to the dissipated power P_{tot} is [3]: $\Delta T = P_{tot} \times R_{th} \approx 1.1 \times 10$°C = 11°C. For maximum reliability always make sure that ΔT do not exceed 35°C.

A better approximation of T_h can now be calculated [4]: $T_h = T_a + \Delta T \approx$ (60+11)°C = 71°C. Again looking at Figure 5, k_T is seen to vary insignificantly for $T_h \geq 60$°C. The approximation $T_h \approx T_a$ used previously for obtaining k_T is thus seen to be quite accurate for these calculations. However, for large ΔT a second calculation iteration, using new k_T-values at the calculated T_h, might be needed to obtain accurate results.

The **minimum specified operational lifetime $\mathbf{L_{op}(T_h,U_R)}$** at T_h = 71°C and rated voltage U_R is given by Figure 6 as $L_{op}(T_h,U_R) \approx 25000$ hours.

The **application-specific operational lifetime $\mathbf{L_{op}(T_h,U_{appl})}$** is now to be calculated. With $q_U = U_{appl} / U_R = 350/400 \approx 0.88$, it is [5]: $k_U = q_U^5 \approx 0.88^5 \approx 0.53$. Finally [6], $L_{op}(T_h,U_{appl}) = L_{op}(T_h,U_R) / k_U \approx 25000/0.53$ hours ≈ 50000 hours.

Result:
Used under working conditions as specified above, a PEH300VY3390M snap-in capacitor should have a minimum lifetime of 50000 hours.