NH knife blade fuses

The history

In 1926, in Germany, a standard was set up for fuses for general purpose mainly for conductor protection. They exist in a encapsulated form with two contacts and a ceramic casing. Until 1945, fuses that consisted of a ceramic casing, normally cylindrical, that containing a replaceable melting element, were usually used for the higher current applications. In 1944 the NH knife-blade fuse was defined in the DIN standard 43620 (Deutsche Industrie Norm). This fuse-link was comprised of a ceramic body, cover plates, knife-blade contacts and an indicator.

NH KTF fuse-links

In 1976 the slow and the fast characteristics were merged into one characteristic, which was also combined with a reduction in the permitted power consumption. This was the beginning of the NH KTF fuses However the market continued to demand smaller versions. As such, in the years that followed, compact versions were launched on the market alongside the normal versions.

NH KTF M fuse-links

As well as electrical protection, the safety aspects of touching the fuses became important. To an increasing degree of protection, the fuses were used in fuse bases, fuse-switchdisconectors and fuse-switches. As a consequence of this, the indicator on the top of the fuse was no longer visible. In the past, Weber had manufactured a fuse with a centre indicator. The application of fuse-switchdisconnectors such as VERTIGROUP and SILAS brings the reintroduction of the centre indicator.

Special features of the WEBER centre indicator:
■ Indicator on the front of the knife-blade fuse
■ Red indicator button
■ Strong wire spring of 4N
■ Operation from 10V upwards

NH KTF MK fuse-links

NH fuse-links with insulated metal gripping lugs were specially designed in order to improve safety from touching the gripping lugs in normal open NH fuse-holders. These fuses were supplied by various manufacturers. This could cause unclear and dangerous situations in electrical service areas. Insulated and live components were used simultaneously. The solution to this problem was sought in the direction of fuse-swiches , fuse-switchdisconectors or as fuse-holders with protective covers. In spite of this, the demand continued to grow for fuses with protection against accidental touching. Weber reacted to this demand with the NH KTF MK fuse with insulated metal removal tags and a centre indicator.

NH LP fuse-links

In the mid eighties of the last century the electricity supply companies indicated that there was a need for fuse-links with lower Watt-losses. Over a longer period of use, the slightly higher cost price was more than compensated for. In order to satisfy this requirement Weber designed the NH LP (Low Power), a fuse-link with a rated voltage of 400 V

Weber NH fuse-links, 7 types in 3 versions

gG 400 V, general purpose, mainly for conductor protection
LP MR centre indicator with live gripping lugs
LP MK centre indicator with insulated metal gripping lugs

gG 500 V, general purpose, mainly for conductor protection
KTF indicator on the top with live gripping lugs
KTF M centre indicator with live gripping lugs
KTF MK centre indicator with insulated metal gripping lugs

gG 690 V, general purpose, mainly for conductor protection
gG 690 V indicator on the top with live gripping lugs

aM 690 V, for motor protection and back-up protection
aM indicator on the top with live gripping lugs

gTr 400 V, for protection of distribution transformer
gTr centre indicator with live gripping lugs

gF 500 V, general purpose, mainly for long conductor protection
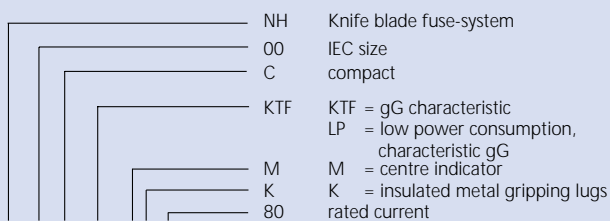**gF** indicator on the top with live gripping lugs

gFF 500 V, general purpose, mainly for extra long conductor protection
gFF centre indicator

Other versions are available on request

Type explanation

NH — Knife blade fuse-system
00 — IEC size
C — compact
KTF — KTF = gG characteristic
LP = low power consumption, characteristic gG
M — M = centre indicator
K — K = insulated metal gripping lugs
80 — rated current

example: NH 00 C {KTF / LP} MK 80

The first letter indicates the interruption range of the fuse
**g** = full-range breaking capacity
a = partial-range breaking capacity

The second letter indicates the category of use
G = general application
M = motor circuits protection (formerly back-up protection)
R = semiconductor protection
Tr* = distribution transformer protection
F* = fast interruption, conductor protection and general use
FF* = extra fast interruption, long conductor protection and general use
*are not mentioned in IEC

With these, the following combinations are possible:
gG full-range, general applications
gM full range, motor protection
aM partial range, motor protection
gR full range, semiconductor protection
aR partial-range, semiconductor protection
gTr full-range, transformer protection
gF full-range, fast interruption
gFF full-range, extra fast interruption

Fuse cross-section

knife contact
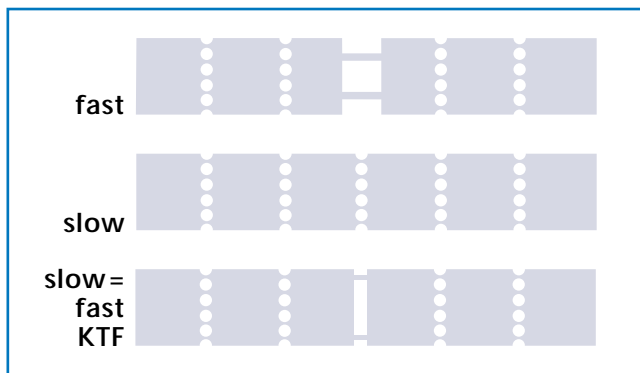fuse element
indicator
filler
enclosure
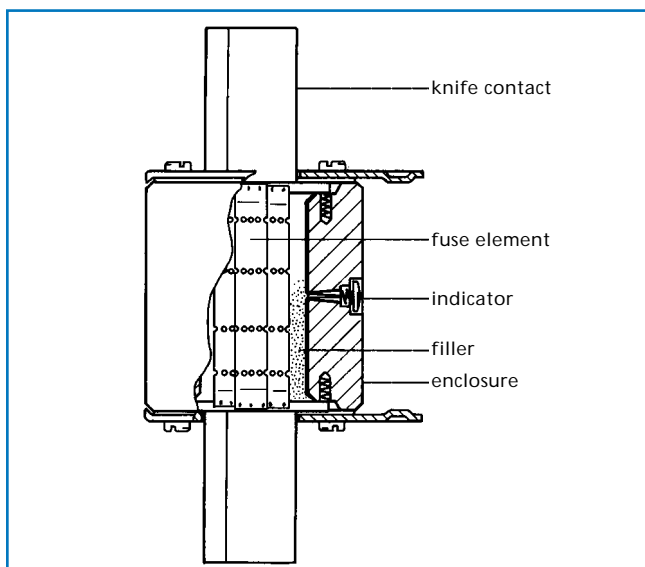
Application

The primary information for use is printed on the fuse, such as: size, rated current, rated voltage, type of current (AC or DC), characteristic, breaking capacity kA, isolated gripping lugs, manufacturers mark, standards, approval marks, CE marking, recycling, production code

The secondary information that needs to be determined in order to choose the most suitable fuse for a given situation must be calculated or read from characteristics.

The most important information for the application of fuses is:
- rated voltage 400 V, 500 V and 690 V AC, 250 V and 440 V DC
- rated current from 2 A in size 000 to 1600 A in size 4a
- size 000 (00C), 00, 1, 2, 3 and 4a depending on the rated current *
- characteristic to protect the object: gG, aM, gTr, gF, gFF
- let-through energy during overload or short circuit

* The sizes 0 en 4 should only be used for replacement; not for new applications.

fast
slow
slow = fast KTF

The fuse-element determines whether a slower or faster interruption occurs.

Operation

The operation of a fuse-link is mainly determined by the construction of the fuse-element, and so a fuse with specific characteristics can be designed for a particular application. The fuse-element determines whether a slower or faster interruption occurs.

During overload, the temperature of the fuse element is so high that the deposited solder (or solder composite) reacts with the fuse element. This reaction results in the diffusion of the deposited solder into the fuse element. This causes the fuse element to become locally more resistive, which in itself results in an accelerated diffusion. This will continue until the fuse element melts. This diffusion is an irreversible process. The fuse technology which is currently in use, takes account of periodic overloading, whereby the delay from diffusion to melting is kept very short compared to the melting characteristic. In this way, the probability of aging through periodical overloading is minimised.

Arcing will be caused by the driving voltage after the fuse-element has melted. This arcing will continue to burn off the ends of the fuse element until the distance between the ends becomes too large to sustain an arc. When this occurs the circuit is broken and no current can flow.
See figure of the interruption on page 5.

Technology

The information needed for the application, calculation and assessment of a fuse will be explained by describing the way in which the fuse operates. For this purpose, oscillograms showing the behaviour when an overload of five times rated current occurs, and when a short circuit current of 100 kA Is occurs are shown respectively.

Explanation of the characteristic

In the event of a long period of overload, the fuse element becomes heated in such a way that a distribution in temperature occurs, with the temperature increasing gradually towards the middle. The melting time of a fuse as a function of the melting current is shown in the melting characteristic. (time/current characteristic, figure X)

Interruption due to overload can be recognised by the fact that the shape of the melted material shows a gradual thickening towards the middle, where the temperature was at its highest during the interruption (fig. A, page 6). If a current of five times rated current is switched on, then the fuse will melt after 2.0 s, as shown in figure Y. The current is maintained after melt down by means of arcing. An increase in the length of the arc means an increase in resistance. This increase will cause the current to drop to zero, until after an arcing time of t_l = 35 ms, the driving voltage falls over the fuse. The total time from overload till arc interrupt, is known as the total clearing time. $t_t = t_s + t_l = 2,035$ s

Interruption as a result of a short circuit can be recognised by the fact that the shape of the melted material shows thickening at regular intervals, because the temperature was the same throughout the device during the interruption (fig. B, page 6). A short circuit current with a possible top value of 100 kA will pass through a fuse as shown in figures Z1 and Z2. After a melting time of 0.42 ms, the interruption starts on all the leftover sections simultaneously. This gives rise to a steep increase in voltage and arcing occurs. Due to the rapid change in current, the self-inductance present in the current chain will cause an over-voltage over the fuse with a top value of 1.5 kV.

The current is limited at a value which is lower than the prospective top value and rapidly decreases to zero. The let-through peak value is known as the cut-off current. After an arcing time of 4.23 ms (the time from when arcing begins to when the arc is quenched) the driving voltage falls over the fuse. The time from short circuit current to when the arc is quenched is known as the total clearing time (melting time + arcing time) $t_t = t_s + t_l = $ **4.65 ms.**

The let-through energy is determined by the construction and the used material of the fuse element. Usually silver or copper is used as the material for the fuse element. The let-through energy in the short circuit region is expressed in the term I^2t. The values are expressed as A^2s.
For certain applications, such as semiconductor protection, the maximum permitted A^2s values for the semiconductors is given,

fig. X

fig. Y
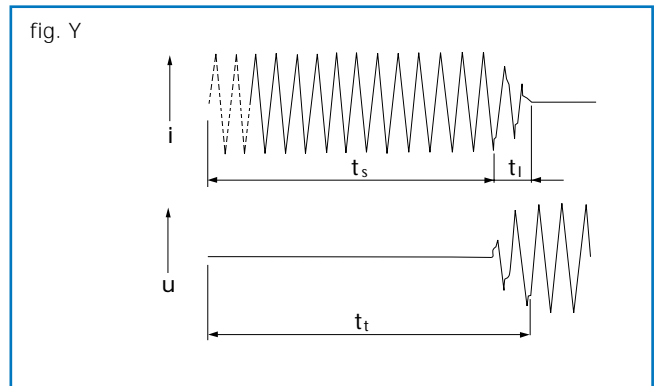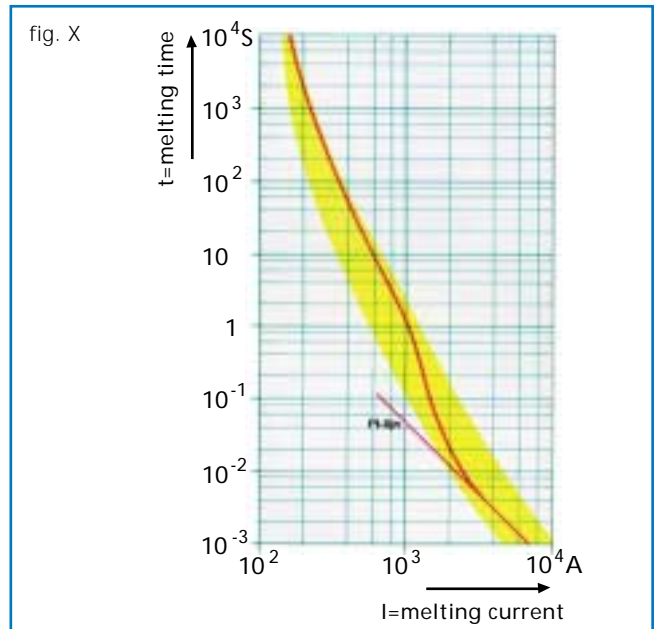
Melting in the overload region

fig. Z₁

Is 100 kA eff

Îd 17 kA

fig. Z₂

Îd 17 kA
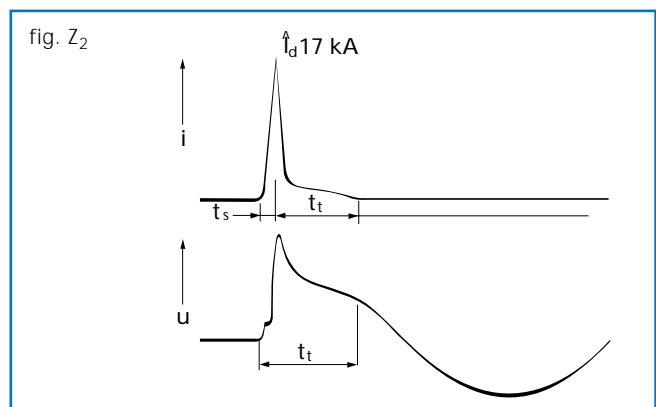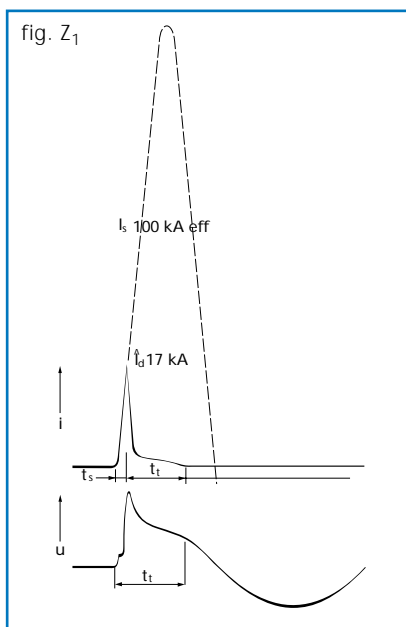
Melting in the short circuit region

so that it can be seen whether these will be protected by the chosen fuse.

The melting energy can be calculated based on the construction of the fuse element and the type of material used in the element.

For very large currents, as shown in the oscillogram on page 5 the melt temperature is reached so quickly that the left-over sections start behaving adiabatically i.e. no heat is given off. So the melt time is a function of the material and the cross-sectional surface area of the leftover material. The melt characteristic in this region can be determined by the following formula:

$I^2t = CA^2$ I = the virtual melting current in Amperes
         t = the virtual melting time in seconds
         A = leftover cross-section in cm^2
         C = the material constant, Cu 10^9, Ag 7×10^8

When a particular high current is reached, the melting characteristic follows an I^2t tangent (melt through I^2t value)

Cut-off current I_c

Because the short circuit current is limited when there are very high currents, as shown in the graph on figure 5, it can be stated that the melt current is similair as the cut-off current.

The cut-off current can be calculated using the following formula; Cut-off current or let-through current $I_c = 11.\sqrt[3]{W}.I_{eff}$.

Where $W = I^2t = CA^2$
I_{eff} = the prospective short circuit current at 50 Hz

For a particular melting pattern, the let-through peak current at a prospective short circuit current, can be derived from the current limiting characteristic.

The ability to limit the current makes it possible to connect equipment with a lower short circuit value directly to the mains.

However, this is still conditional on the melting pattern complying with the mains short circuit power, and with the connected equipment being able to deal with the cut-off current energy.

Critical current region.

The amount of energy released at interuption which can be regarded as the most critical, occurs at the point where the fuse begins to limit the current.

In accordance with IEC 60269, the highest arcing energy occurs when the let-through value of the current lies between $0,60\sqrt{2}$ and $0,75\sqrt{2}$ of the prospective short circuit current.
Derived from the IEC definition, a useful rule of thumb is that the actual value is between 3 to 4 x the melting current when the melting time is 10 ms.
The 10 ms melting time and the associated current can be read from the time/current graph.

Overload

fig. A

Short circuit

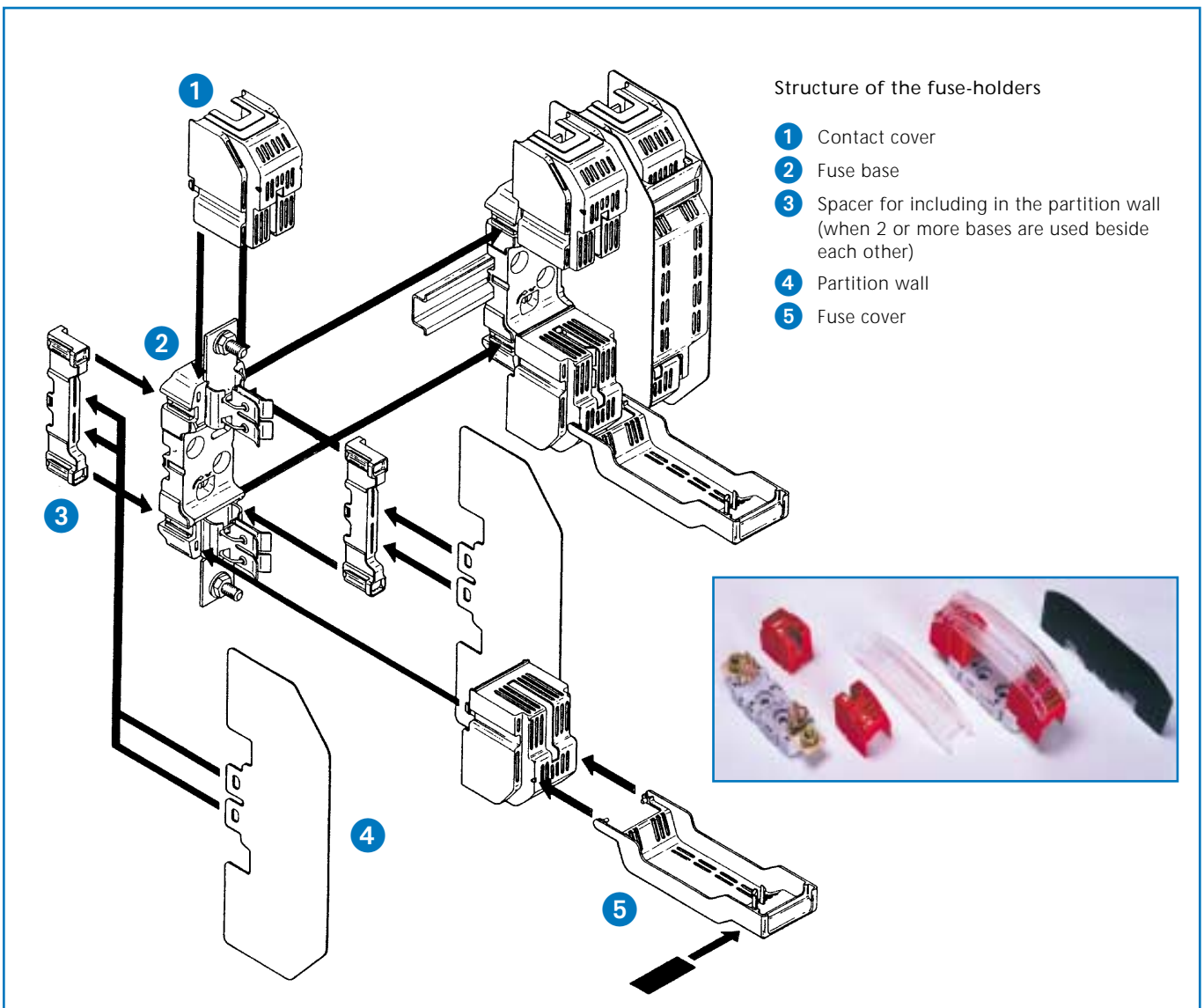*fig. B*

NH fuse-holders

History

NH fuses consist of a fuse-link and a fuse-holder. In the past, these were ceramic carriers on which terminals with bolts were used. Later the terminals were fitted with springs.

Later still, with the arrival of high-quality plastics, the holders were made from plastic. This is not to say that holders made from or including ceramics are obsolete. These are still used when high temperature influences may be expected to occur.

With the introduction of the insulated gripping lugs, contact covers were also introduced to make the whole device safe-to-touch. Nowadays most fuse-holders are made from plastic, with or without contact covers and/or fuse covers. The fuse-holderss must comply with the requirements for maximum Watt-losses, among other things, as specified in the standards.

NH fuse gG 500 V with centre indicator

Structure of the fuse-holders

1. Contact cover
2. Fuse base
3. Spacer for including in the partition wall (when 2 or more bases are used beside each other)
4. Partition wall
5. Fuse cover

Structure of a fuse-holder

fuse-holder, safe-to-touch, single

Standards

The NH fuse-holderss are suitable for 690 V (AC and DC) and must satisfy IEC 60 269 part 1, part 2 and part 2-1. (IEC-EN-NEN 60 269). The VDE 0636 and DIN 43620 standards are incorporated in the IEC standard.

Connections to the fuse-holders

The connections to the fuse-holders can be:

- Bolted connections (when using cable shoes)
- Brace(clamp) connections (for direct connection to the conductor)

In addition various combinations can be made, depending on the type, shape and material of the conductor. For example, brace connections (prisma clamps) for aluminium cable. When making the connections, the correct tightening tools as well the given torques, as specified by the manufacturer, must always be used.

fuse-holder single

fuse-holder triple
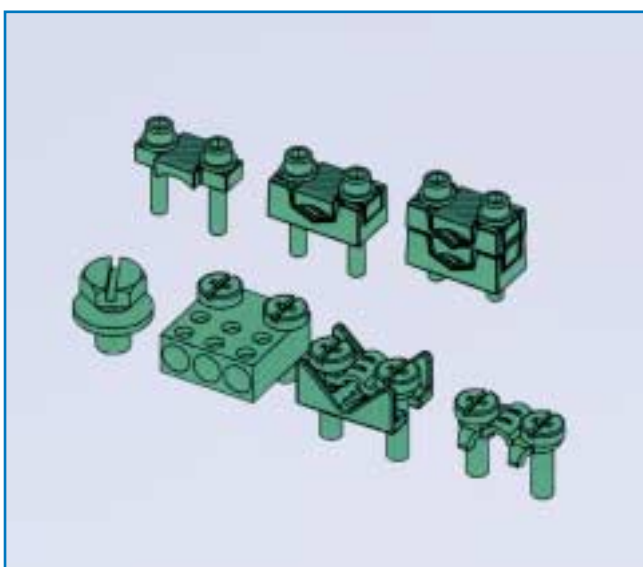
Various connections

Knife-links

Knife-links are used to connect or isolate (open) current paths. This may never occur with fuse-holders which are under load (see safety procedures), because a holder is not a load switch. Knife-links are available in 2 versions

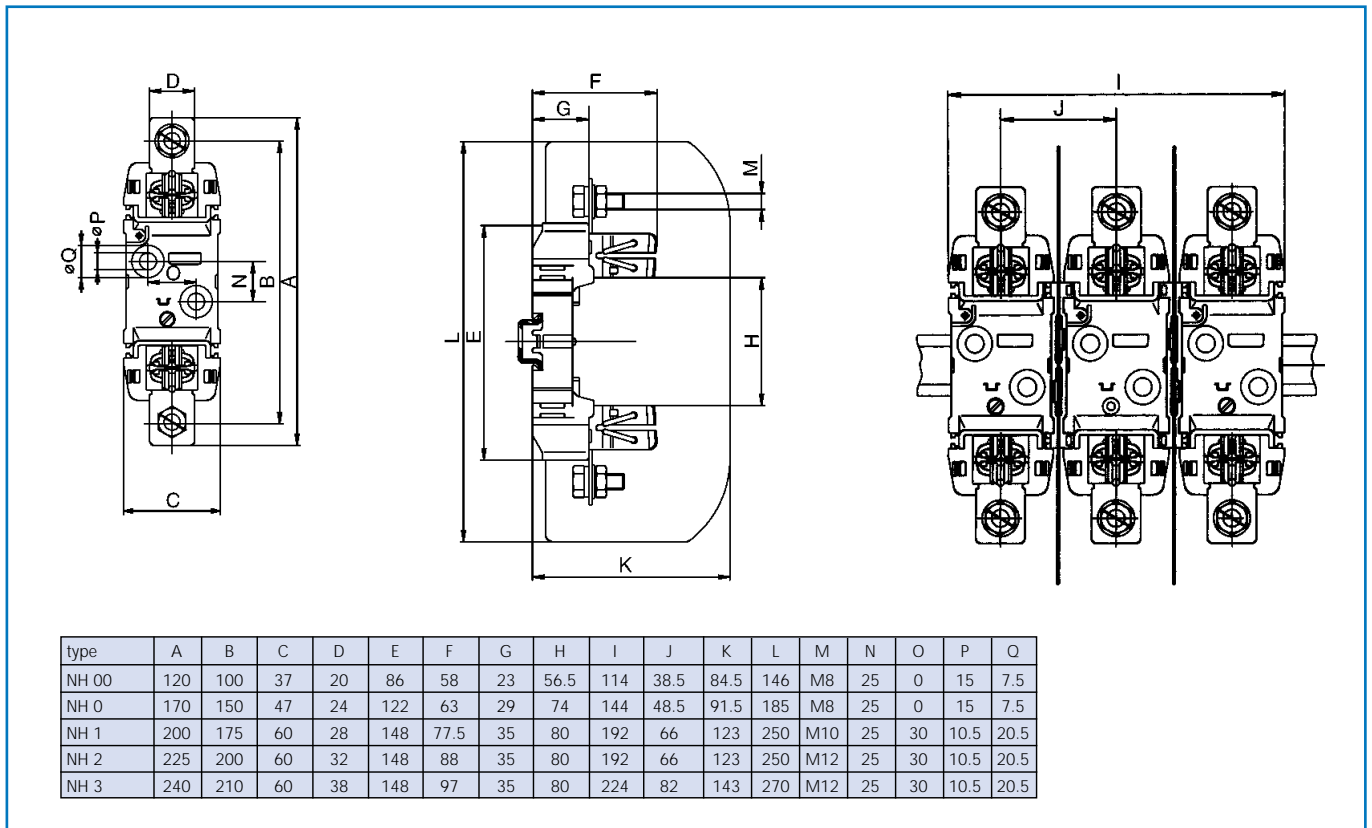■ with insulated plastic removal tags
■ with live metal removal tags

Fuse replacement handles

A fuse replacement handle is necessary for inserting and removing fuse-links. The fuse replacement handles are suitable for fuse sizes NH 000 (00C) through NH 4. The fuse replacement handle must be fitted with a locking mechanism to ensure that the fuse-link does not fall out of the handle during insertion or extraction. Fuse replacement handles which include a glove are available for extra safety in accordance with the procedures.

Knife links with insulated gripping lugs

Fuse replacement handle with glove

Fuse-holders dimensions

type	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
NH 00	120	100	37	20	86	58	23	56.5	114	38.5	84.5	146	M8	25	0	15	7.5
NH 0	170	150	47	24	122	63	29	74	144	48.5	91.5	185	M8	25	0	15	7.5
NH 1	200	175	60	28	148	77.5	35	80	192	66	123	250	M10	25	30	10.5	20.5
NH 2	225	200	60	32	148	88	35	80	192	66	123	250	M12	25	30	10.5	20.5
NH 3	240	210	60	38	148	97	35	80	224	82	143	270	M12	25	30	10.5	20.5

Sketches with dimensions
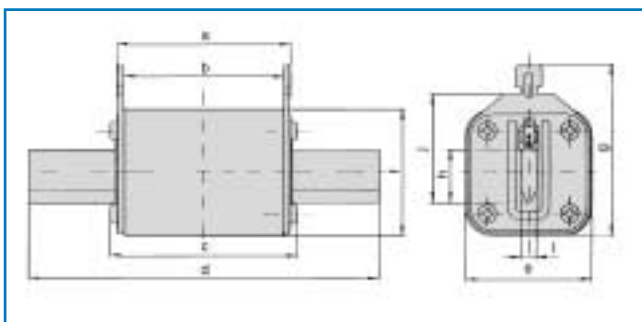
type	a	b	c	d	e	f	g	h	i	j
NH 00 C	49	45	53	78.5	21	37	51	15.2	6	35
NH 00	49	45	53	78.5	30	45	59	15.2	6	35
NH 0	68	62	72	125	30	45	59	15.2	6	35
NH 1 C	68	62	72	135	30	45	64	15.2	6	40
NH 1	68	62	72	135	50	50	64	20.2	6	40
NH 2 C	68	62	72	150	50	50	72	20.2	6	48
NH 2	68	62	72	150	58	58	72	26.2	6	48
NH 3 C	68	62	72	150	58	58	84	26.2	6	60
NH 3	68	62	72	150	68	68	84	32.2	6	60
NH 4a	91	83	97	200	100	109	124	50	6	85

Size overview

The size (dimensions of casing and blades) of fuses must match the size of the fuse-holders or the device. The size of the fuses is expressed in numbers.

Fuse-holders size	Rated current In up to Ampere	Suitable for fuse
000 (00C)	100 A	NH 00C = (000)
00	160 A	NH 00
1	250 A	NH 1
2	400 A	NH 2
3	630 A	NH 3
4a	1250 A	NH 4a*

* Rated current up to 1600 A is permitted. Size 4a fuse-holderss are only available in the safe-to-touch version with "flap lid"
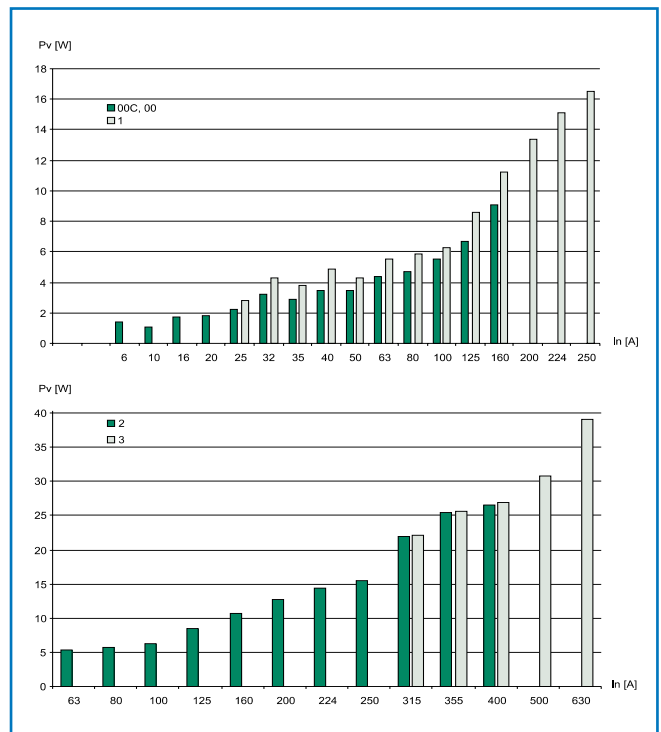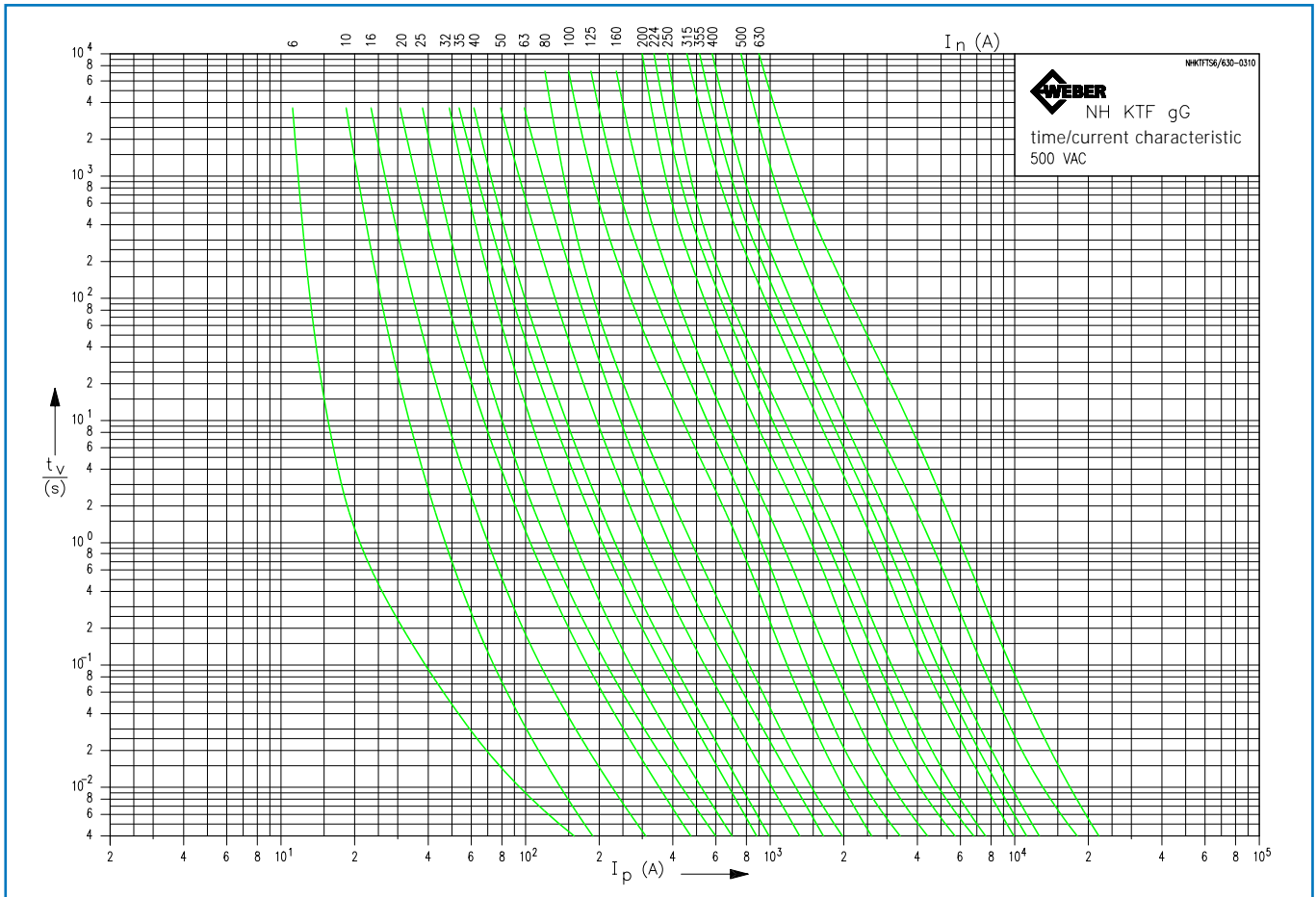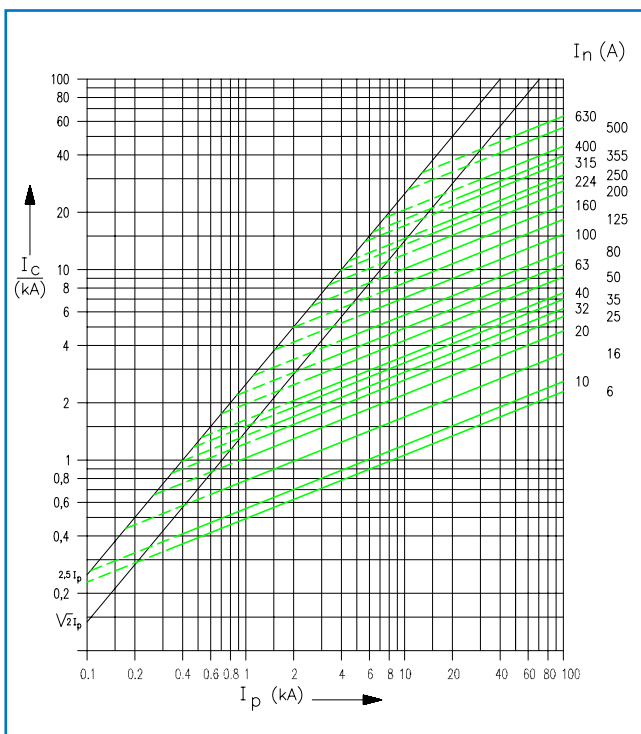
gG 400 V

time/current
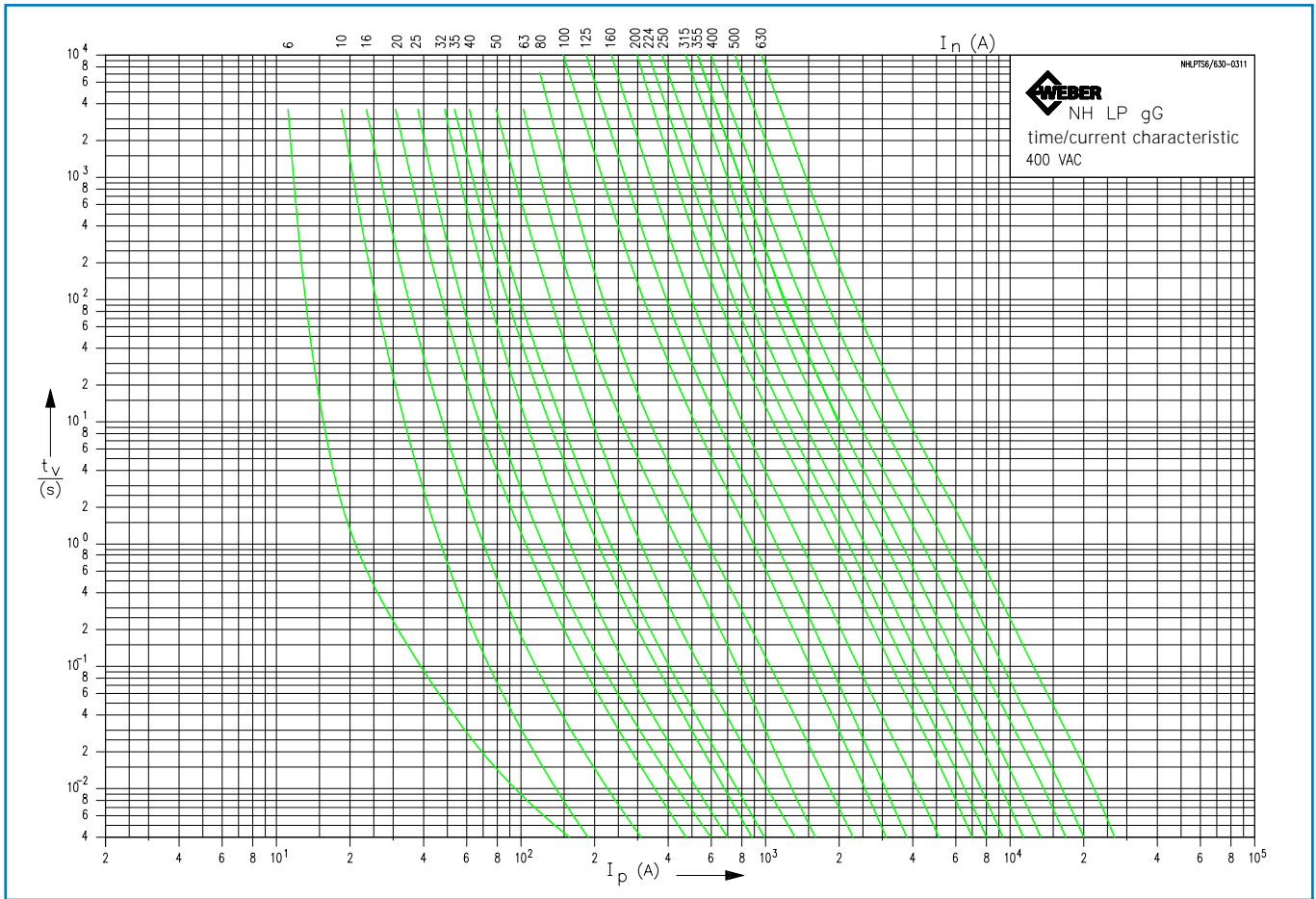
NHLPTS6/630-0311

WEBER
NH LP gG
time/current characteristic
400 VAC

I_n (A)

$\frac{t_V}{(s)}$

I_p (A)

cut-off current

I_n (A)

$\frac{I_C}{(kA)}$

I_p (kA)

Watt losses

Pv [W]

■ 00C, 00
□ 1

I_n [A]

Pv [W]

■ 2
□ 3

I_n [A]

WEBER

gG 500 V

time/current

NH KTF gG
time/current characteristic
500 VAC

NHKTFTS6/630-0310

I_n (A)

$\frac{t_v}{(s)}$

I_p (A)

cut-off current

I_n (A)

$\frac{I_c}{(kA)}$

I_p (kA)

Watt losses

Pv [W]

■ 00C, 00
□ 0, 1C
□ 1, 2C

In [A]

Pv [W]

□ 2, 3C
■ 3

In [A]
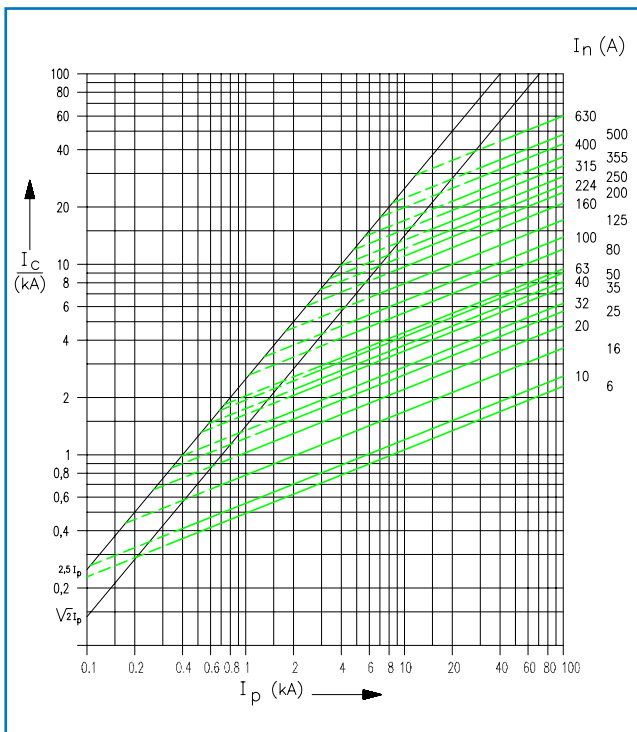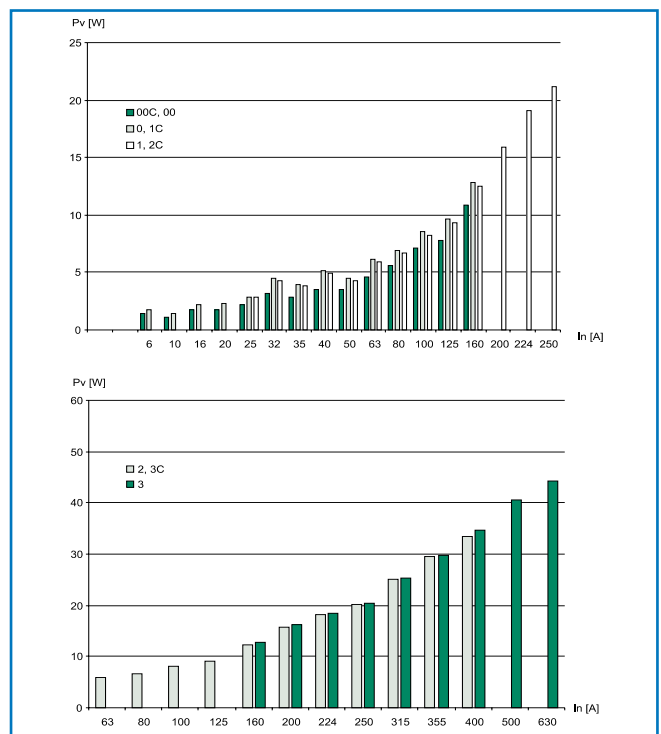
gG 690 V

time/current

NHgGTS10/400-0309

WEBER
NH gG 690
time/current characteristic
690 VAC
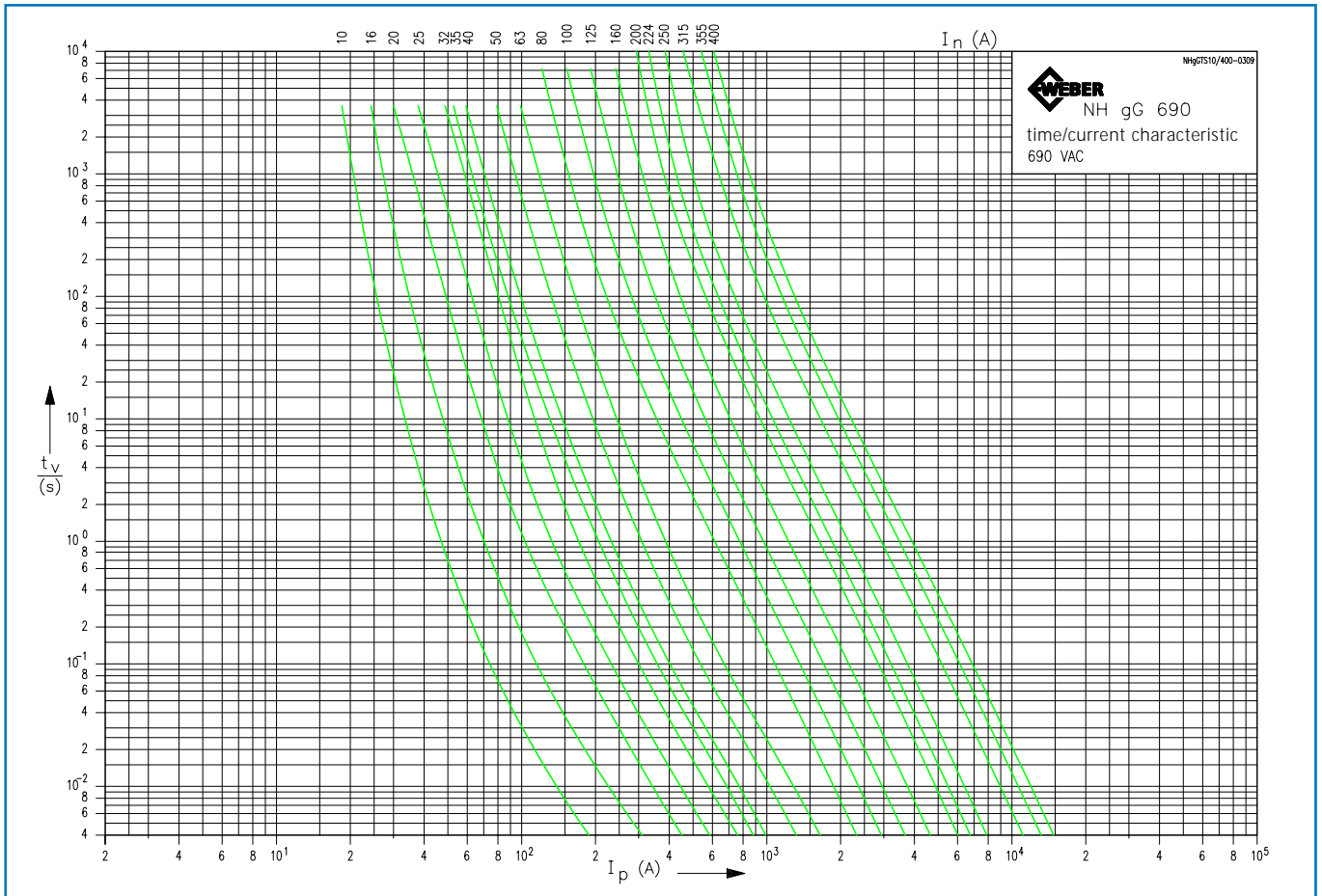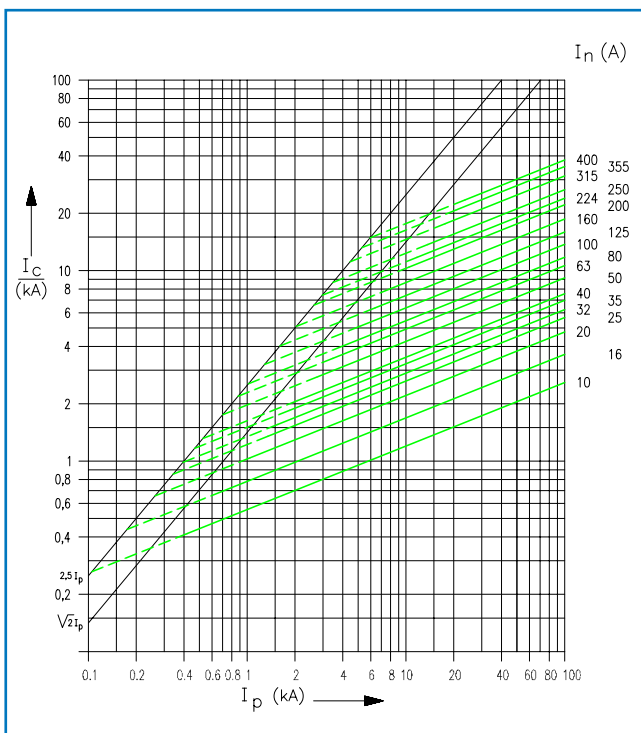
cut-off current

Watt losses

aM 690 V

time/current

NHaM690TS40/400-0311

WEBER
NH aM
time/current characteristic
690VAC

cut-off current

Watt losses

WEBER

gTr 400 V

time/current

NH gTR
time/current characteristic
400 VAC

S_n (kVA)
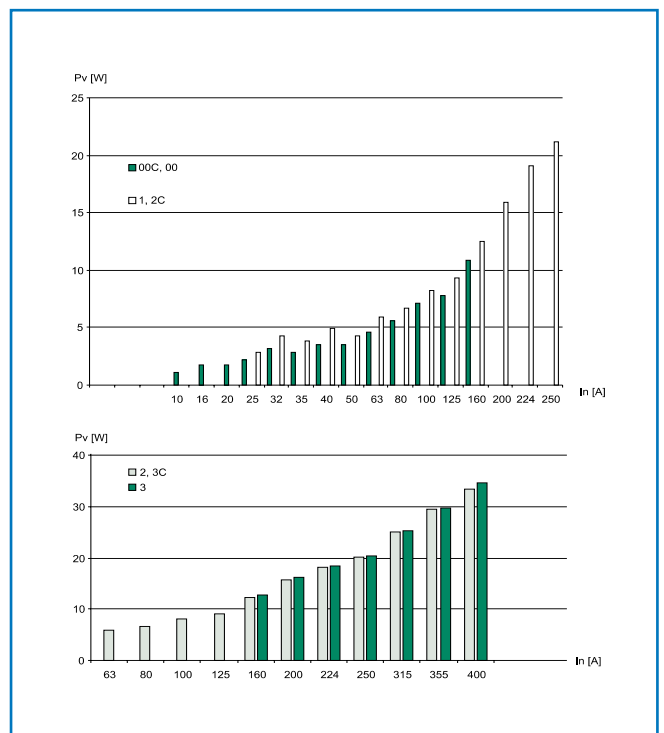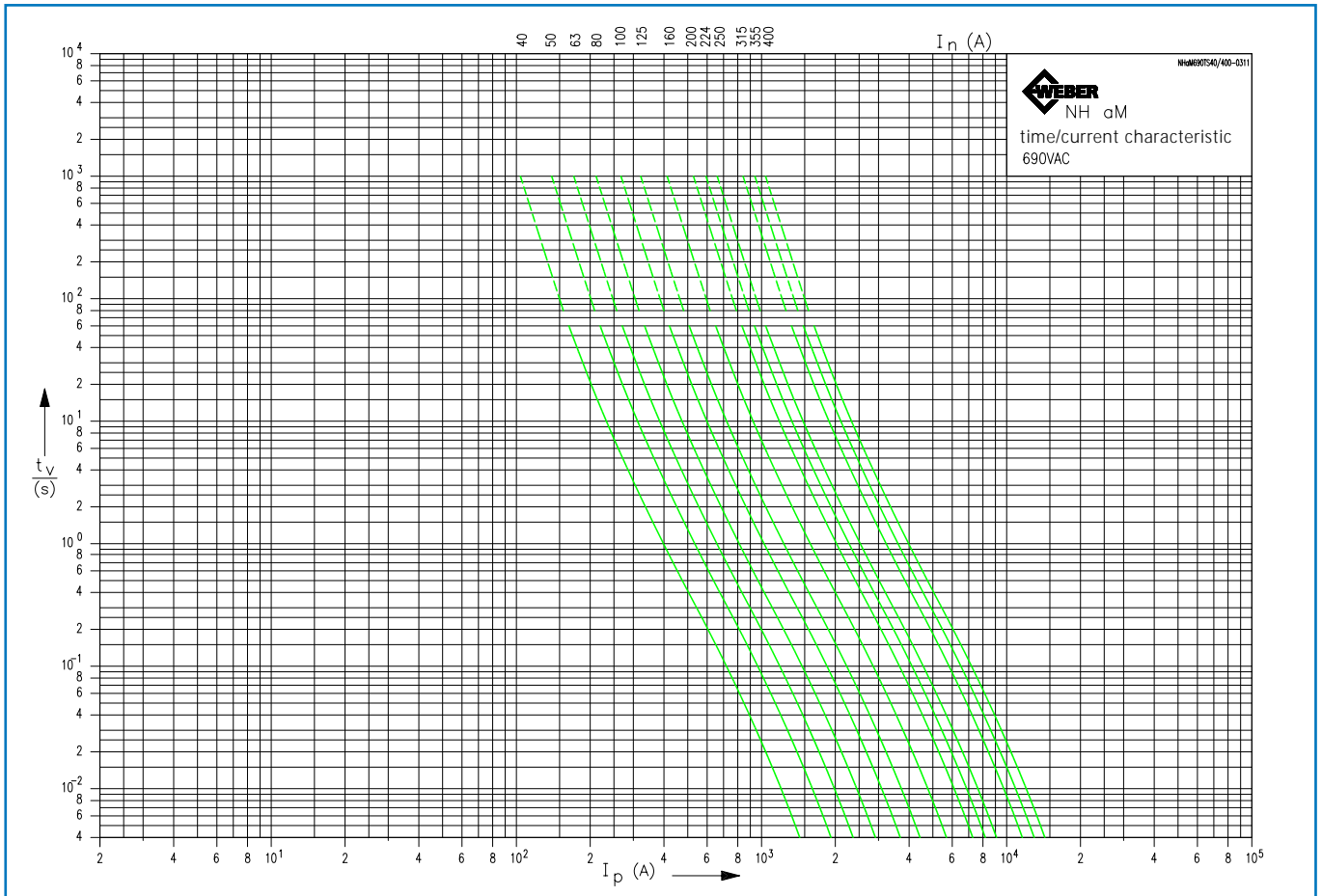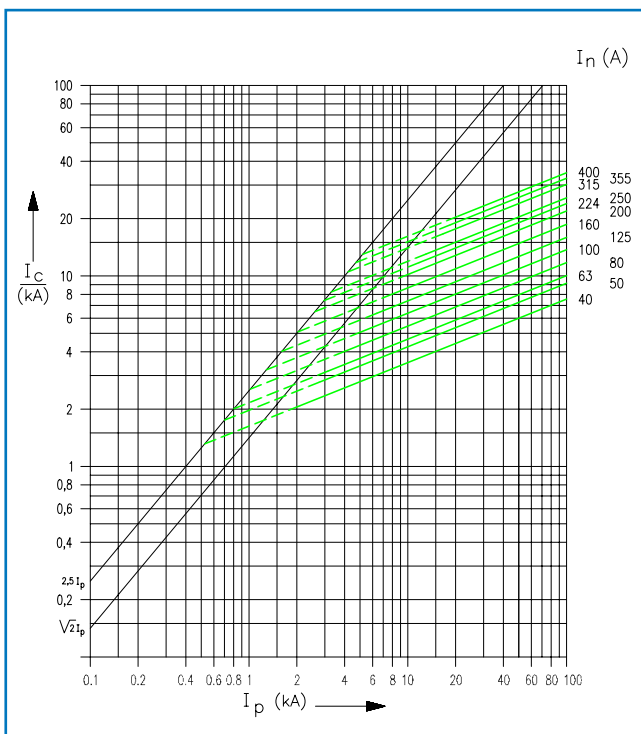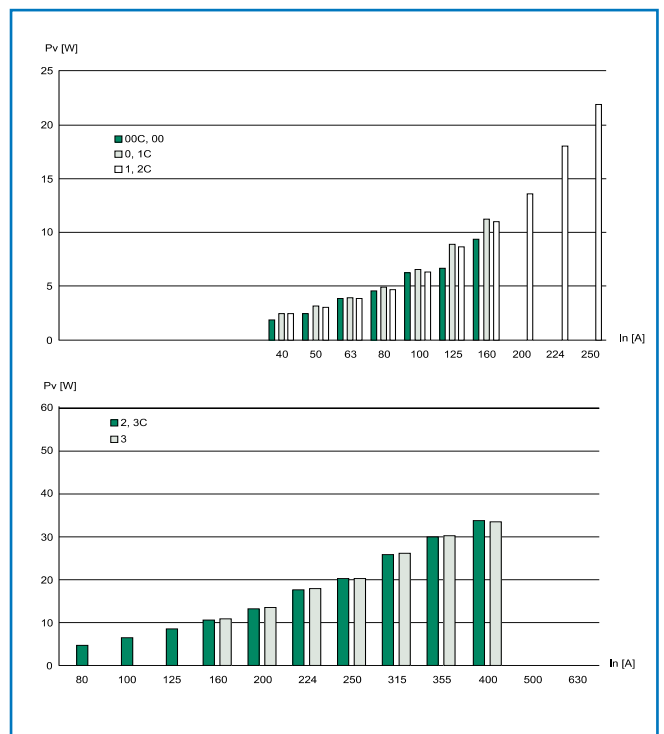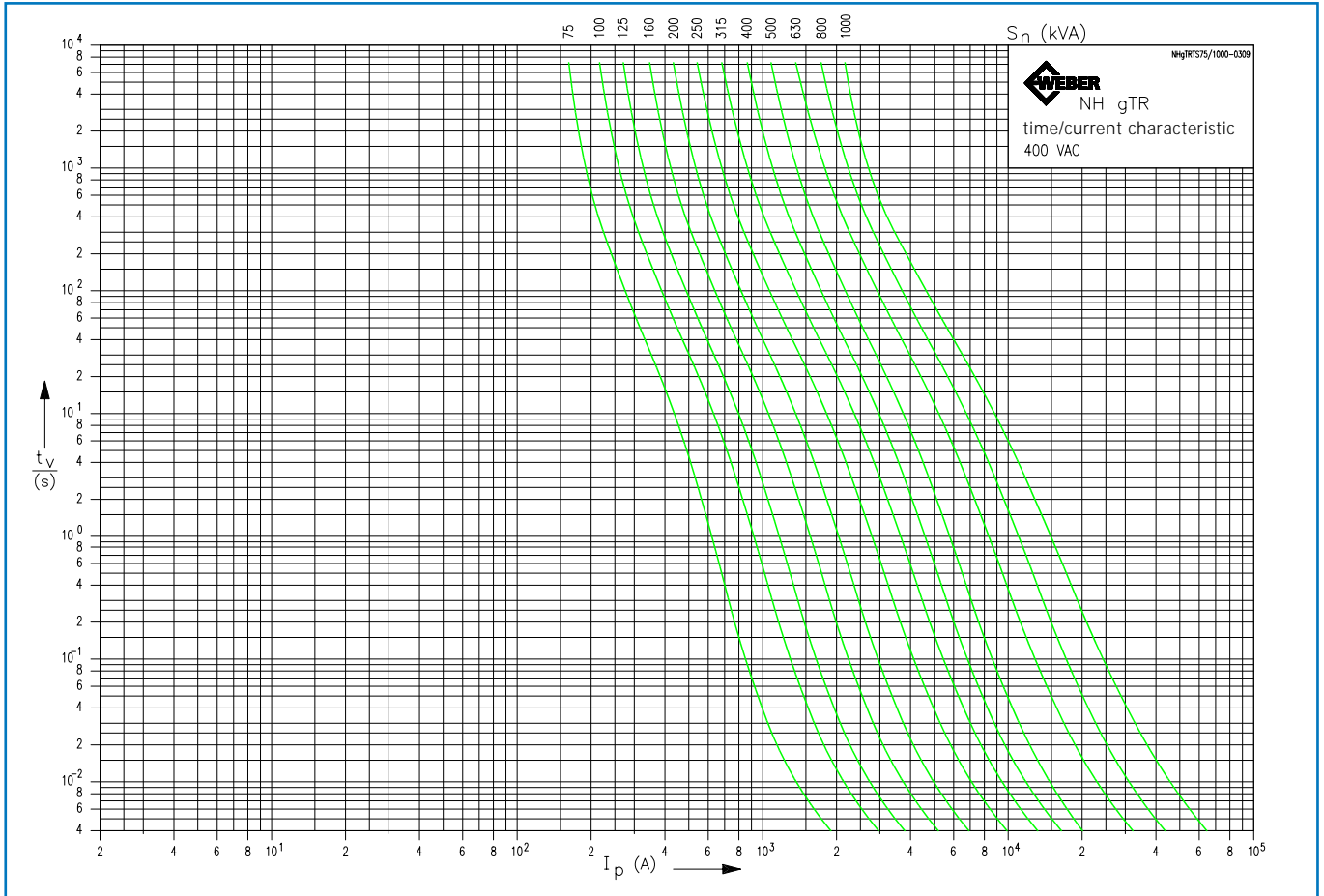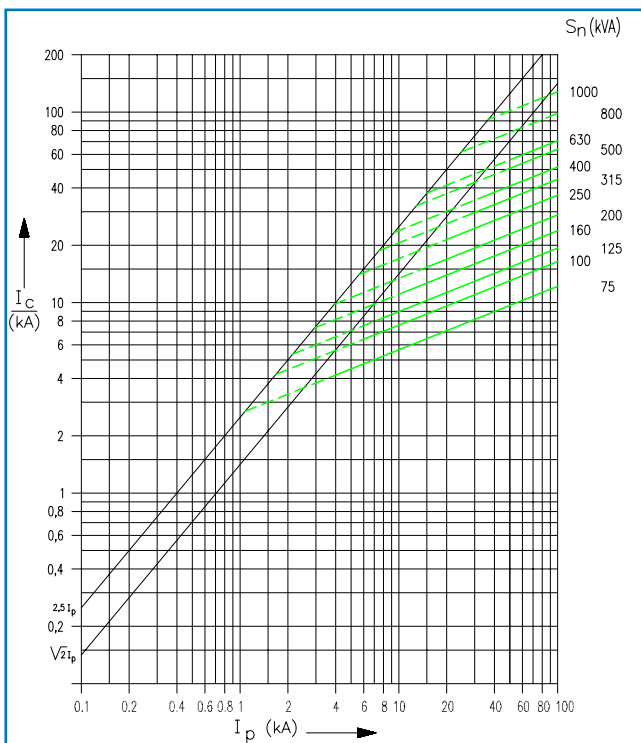
cut-off current

Watt losses

gF 500 V

time/current

NHgFTS16/630-0311

WEBER
NH gF
time/current characteristic
500 VAC
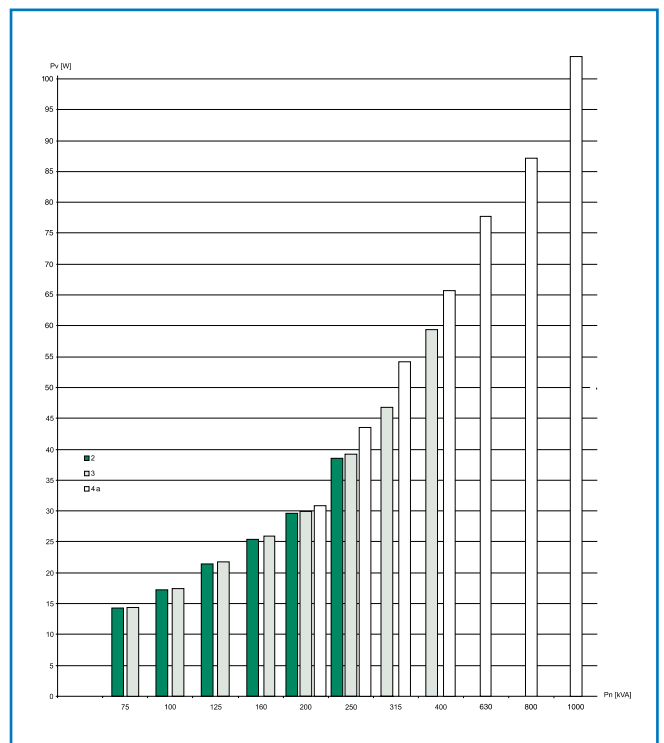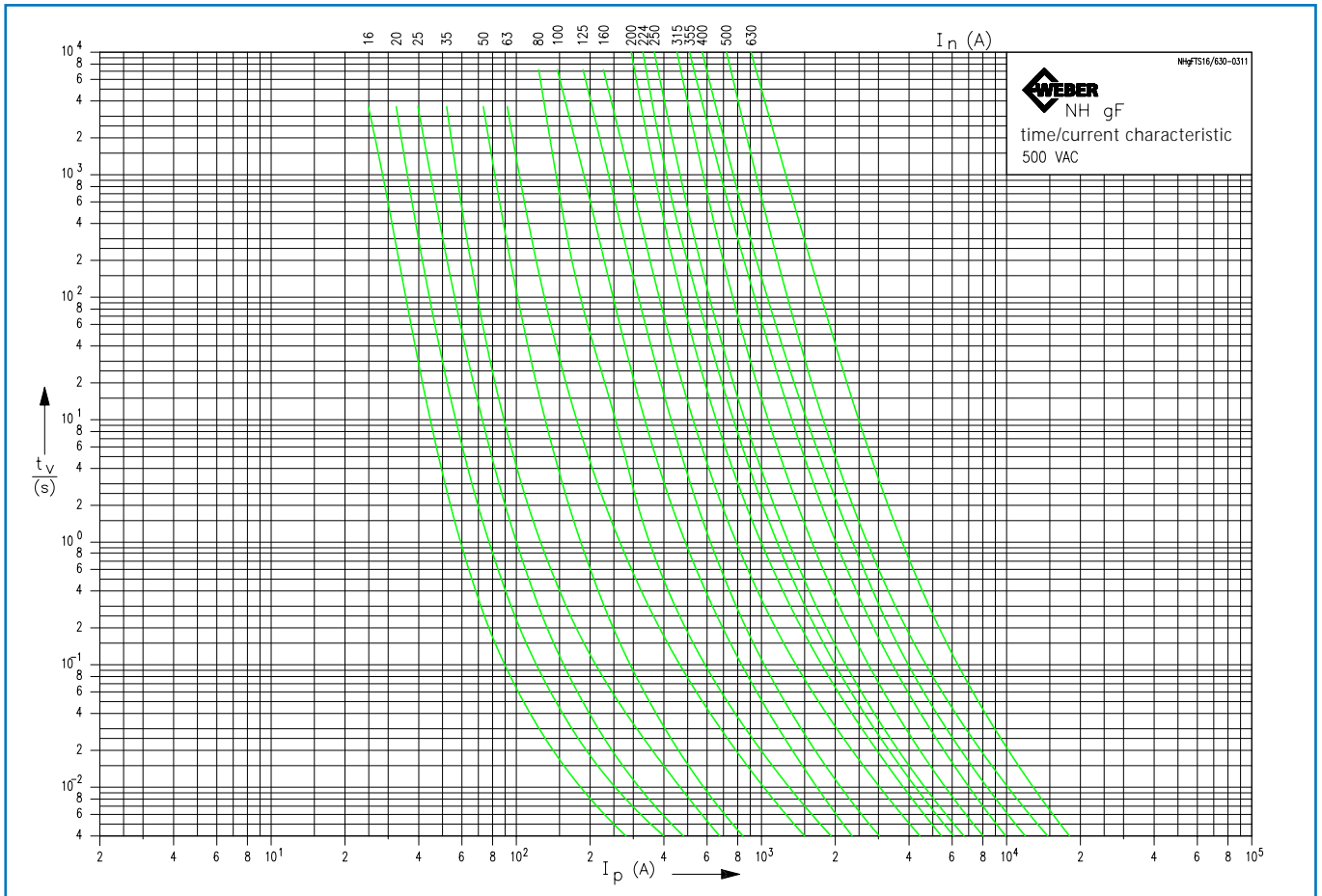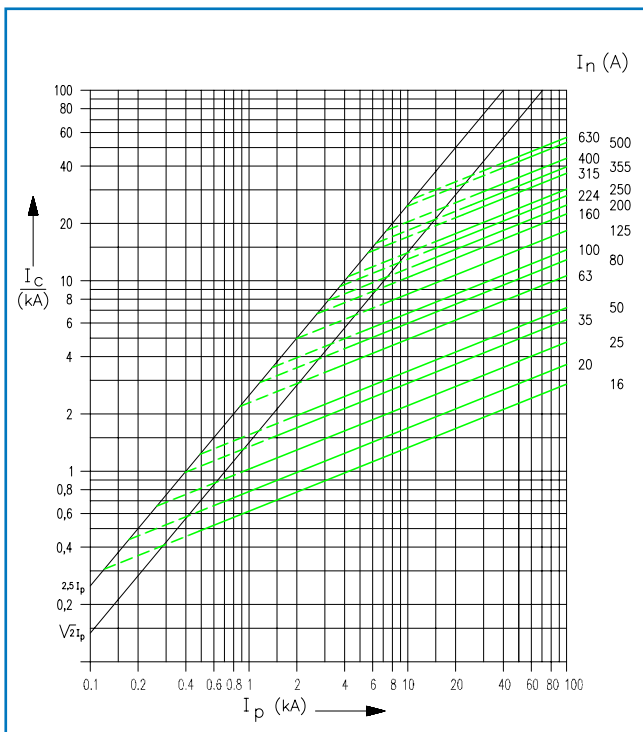
cut-off current

Watt losses

gFF 500 V

time/current

NH gFF
time/current characteristic
500 VAC

NHgFFTS80/315-0311

I_n (A)

$\frac{t_v}{(s)}$

I_p (A)

cut-off current

I_n (A)

$\frac{I_C}{(kA)}$

I_p (kA)

Watt losses

P_v [W]

P_n [kVA]
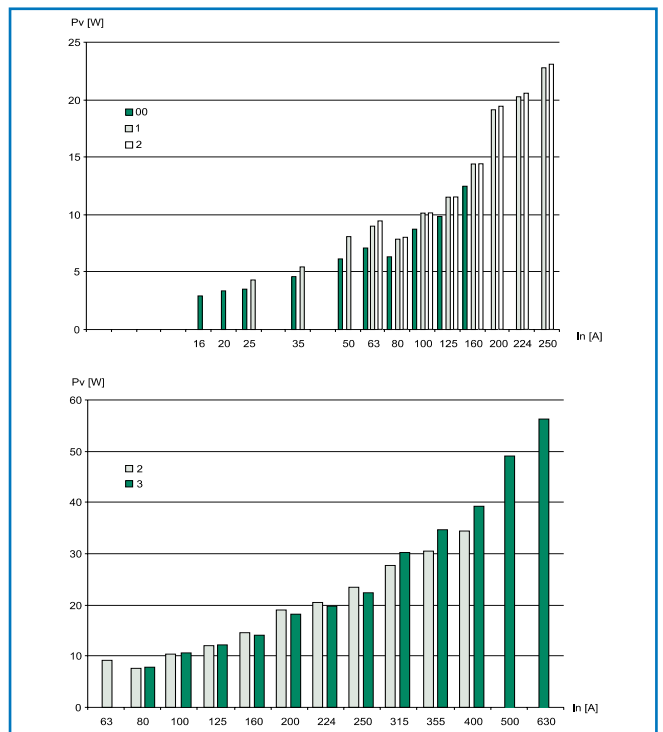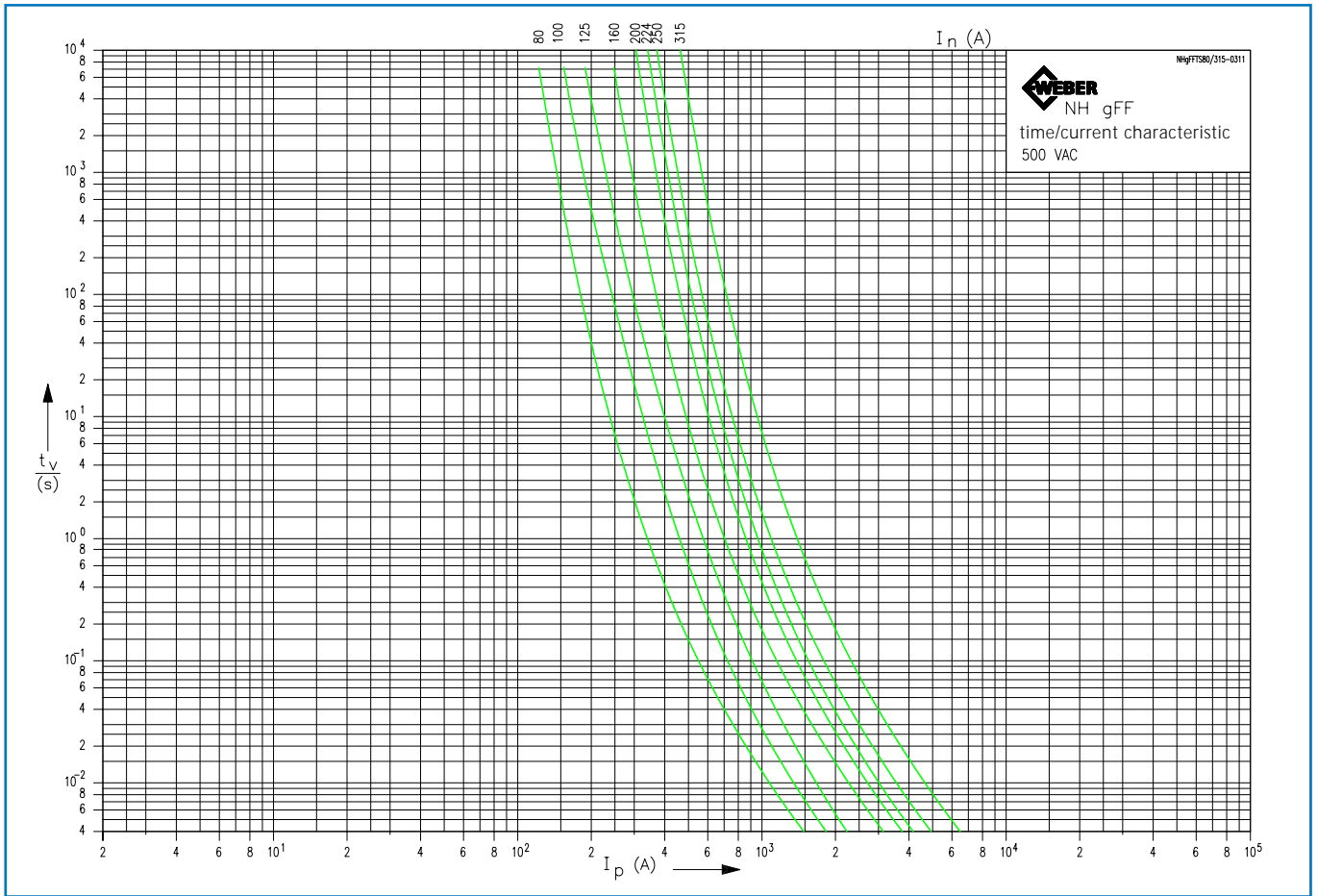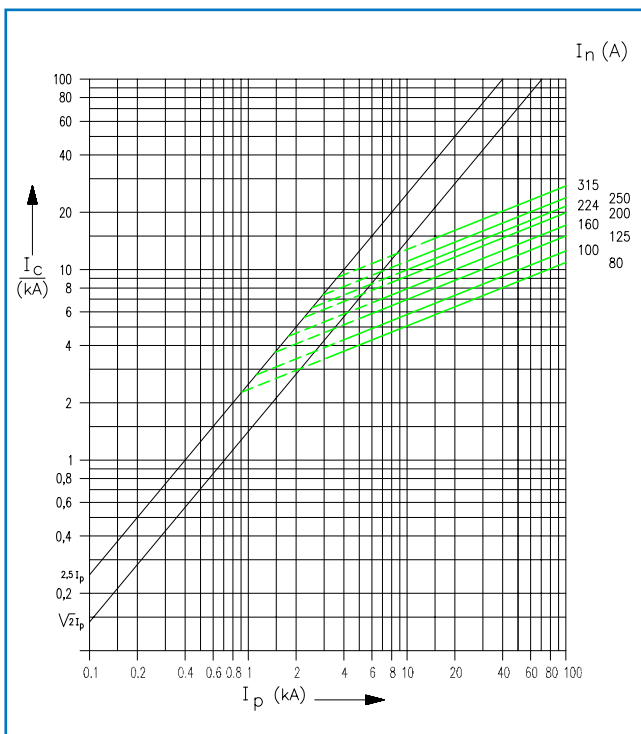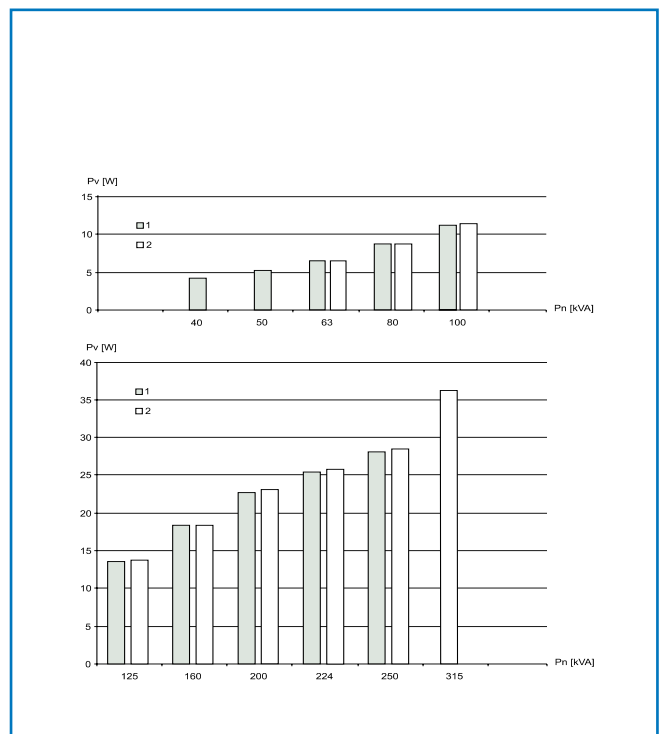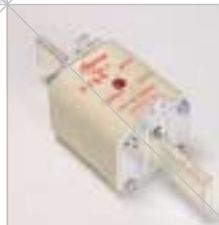
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