



300i and 300p Nagra stereo tube amplifiers  
**Development review**

## 1. GENERAL OVERVIEW

### 1.1 Tubes: still a seductive potential

Many discoveries and breakthroughs date back to the early decades of audio history and their technology are still used in today's electronics. The schematics, upon which many of today's units are based, are frequently an updated form of those conceived a long time ago, and modified according to the evolution of the electronic components.

Among the long living heritage, one finds the vacuum tube – or valve. This invention from the beginning of the 1900's, remains attractive by its qualities that even today the silicon transistor has not managed to surpass. The recent return to the market of a wide range of tube equipment is testament to the renewed interest by numerous manufacturers and a public keen on these solutions.

Does this mean that a piece of valve equipment is superior to a transistor equivalent? This question should not be asked in this manner, because it is possible to create excellent – or mediocre – pieces of equipment using both technologies... However it is true that by putting the most modern technology around the valves, it is possible to draw a maximum from this technology and achieve outstanding results.

This is exactly the Nagra approach. In parallel with the transistorized Hi-Fi equipment and professional digital audio recorders, the company regularly develops new valve equipment. For 2011, Nagra 60<sup>th</sup> anniversary, it will pay respect to the mythical audio tube – the 300B, by launching two units designed around these tubes: the Nagra 300p power amplifier and the 300i integrated power amplifier.

### 1.2 Mythical 300B

Introduced in 1938, the 300B was initially used in the amplification stages of telephony relay equipment (which were perfected in the laboratories of the BELL telephone company), and in the ever improving sound installations of projection rooms converted to cinemas. Discovering its potential, the high fidelity pioneers took it up quickly, achieving remarkable results for the period. For generations, engineers have remained loyal to the 300B, considering it as the "king of tubes".

One must admit that this tube was very well designed, offering qualities that made a name for the group to which it belongs: directly heated triodes. This type of valve construction is simple and lends itself particularly well to sound amplification, particularly by its linear behaviour, low absolute distortion (still lower than today's power transistors) and an exceptional harmonic spectrum. Other excellent triodes, more powerful, such as the imposing 845 honoured in the Nagra VPA amplifiers, appeared later, but they were unable to dethrone the pioneering 300B.

It was the specialities of this tube that inspired the Nagra engineers to start the development to optimise all its characteristics. This decision was even more attractive because the 300B is in plentiful supply – it is built by several manufacturers around the world – and its cost has become much more reasonable than a few years ago.

## **1. DEVELOPMENT OBJECTIVES**

### **2.1 Engineering elegance**

Nagra engineers have put the severity of the electronic precision in the centre of the specifications of the 300i and 300p. They have been particularly careful to achieve this objective by using a conception to purify the circuitry, without compromising elements of comfort and security, expected in modern equipment. They have chosen a conventional approach where possible and application of the very latest technology wherever improvements could be achieved.

### **2.2 Excellent handling of the entire frequency response**

The reproductive neutrality was an objective of utmost importance. The 300B is renowned for its musicality, the delicacy of its medium and the three dimensional presence it gives to its interpretations. The Nagra 300i and 300p are not only references to these criteria but also push the limits currently achieved by this type of tube in terms of low and ultra-low frequencies.

### **2.3 Realistic power in the context of current loudspeakers**

In power terms, Nagra has opted for a circuit design drawing a realistic power from the 300B to comfortably drive speakers with intermediate sensitivity, that are numerous in today's market. It is a class A push-pull configuration, allowing 20 Watts RMS of output power per channel. Such a construction contributes to lower parasitic power supply noise, coming from the high voltages and/or the filament heater voltages.

### **2.4 Silent and stable operation**

The silent operation is precisely a point which the engineers focused upon, as, on this front, directly heated triodes are delicate to implement. By design, they have a tendency to amplify noise in the power supply, particularly around the filament heater frequency. The powering circuits were therefore designed to supply extremely clean, and perfectly stabilised, voltages. In addition, the selection and dimensions of the components, both active and passive, was made in respect of the most stringent noise requirements.

The overall measurements on the supplies and the configuration of the circuits enabled the natural tendency of these triodes to oscillate to be radically reduced, through the grid-anode coupling capacity. The absence of all feedback at the final stage gives this amplifier remarkable stability. All types of loads can be connected without risk of oscillation.

### **2.5 Exemplary performance with all types of 300B**

Engineering pushed the circuits, and component quality, used to allow the 300i and 300p to give a non-fluctuating neutral performance, irrespective of the type of 300B used. The possibility to swap tubes of one manufacturer to another leaves the user with the freedom to test all the different models available.

### **2.6 Integration in the range**

The aspect of the amplifiers, had to match the Nagra standards in terms of dimensions, finish, quality of execution and durability. The 300i and 300p fit harmoniously into the company's current product range. They are built by the same teams in the same laboratories as the professional recorders, with the same norms and exactitude.

### 3. DESCRIPTION OF THE ELECTRONIC PART

The NAGRA triode amplifiers are built around 6 printed circuits for the 300i and 7 for the 300p. These circuits are multi-layer epoxy-glass boards with gold plated tracks built to military specifications. They hold all the electronic components of the units, which were chosen with the toughest tolerances, reliability and behaviour for listening.

The ground-plane of the circuits adopts a “star” configuration, and is organised around a common earthing point. This lay-out, that favours the most natural flow of ground flux, avoids creating loops and generation of parasitic hum.

The earth point of the amplification circuit is made at the base of the drivers instead of the inputs, again assuring very clean earth flux, and silent operation.



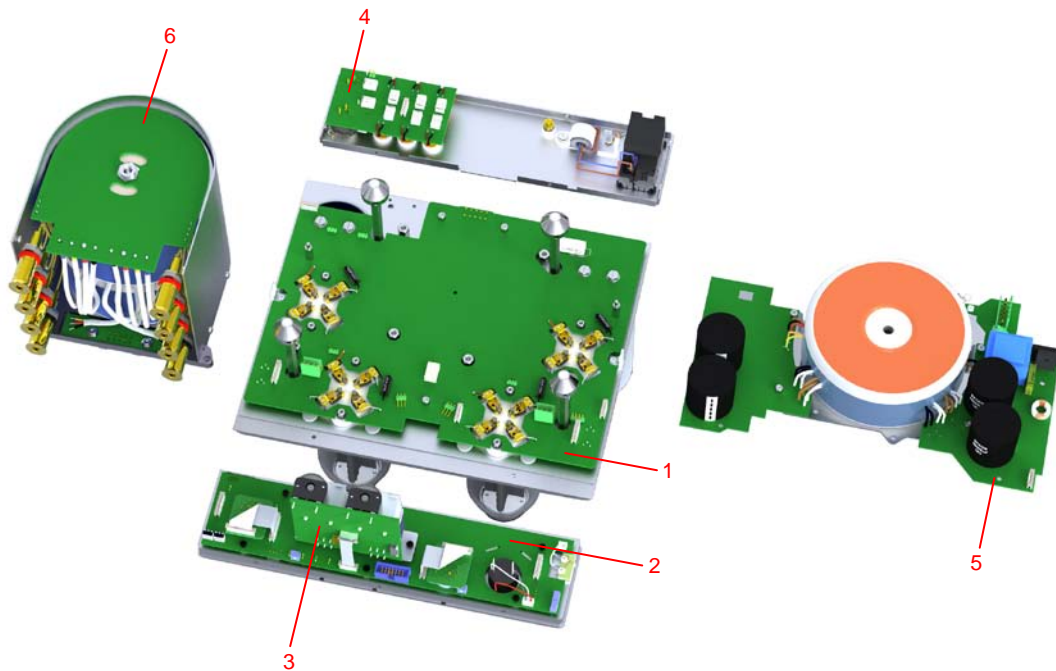
Top view of Nagra 300i



Nagra 300i: internal view of the left side



Nagra 300i: internal view of the right side



1. Motherboard amplifier circuit 2. Security and management circuit 3. Control circuit (volume and balance)  
4. Input circuit 5. Power circuit 6. Output transformer module

### 3.1 Input circuit

The input printed circuit of the 300i and 300p is identical but equipped with different components, corresponding to the different specifications of the two units.

#### Nagra 300i

The integrated 300i is designed to accept 4 different sources, on 3 sets of Cinch and one pair of XLR connectors. The Cinch inputs are isolated from ground which renders the signal pseudo-symmetrical up to the amplification circuit. The input selection is handled by high quality relay pairs. Only the ground of the active input is used, all the others are left out of circuit to assure that no parasitic noise sources are created.



The inputs A, B and C have a sensitivity of 2 V rms, and input D goes up to 4.1 V rms. A combination of coils and capacitors filter each input from radio-magnetic interference.

#### Nagra 300p

A jumper on the rear panel allows the selection of two pairs of connectors to connect the amplifier to its preamplifier by either Cinch or XLR, and the internal selection is made with a relay. As with the 300i, the inputs are filtered from RMI.

#### **3.2 Control circuit (300i only)**

The volume and balance controls on the 300i are mounted on a dedicated circuit. Each operates a low noise unity gain operational amplifier, in front of which are motorised Blue Velvet potentiometers made by Alps. These pots are renowned for their precision and the matching of their tracks maintains their excellent characteristics over a long period.

#### **3.3 Motherboard**

The driver and power stages are grouped on a single motherboard located below the 300B tubes.

#### Driver stage

Based on an unusual circuit design for a tube amplifier, this stage drives the 300B's with precision and a perfect stability.

A high performance ultra low noise operational amplifier is fitted to the input to match the impedance between the stages and the transformation of the signals from symmetric to asymmetric. The signal is then phase shifted by other identical operational amplifiers before reaching the driver stage. The driver stage is based on a set of discreet high voltage transistors, mounted in a metal T0-5 box for good thermal dissipation. The 240 V supplied to these transistors as well as the +/- 10 V for the operational amplifiers are carefully regulated and filtered.

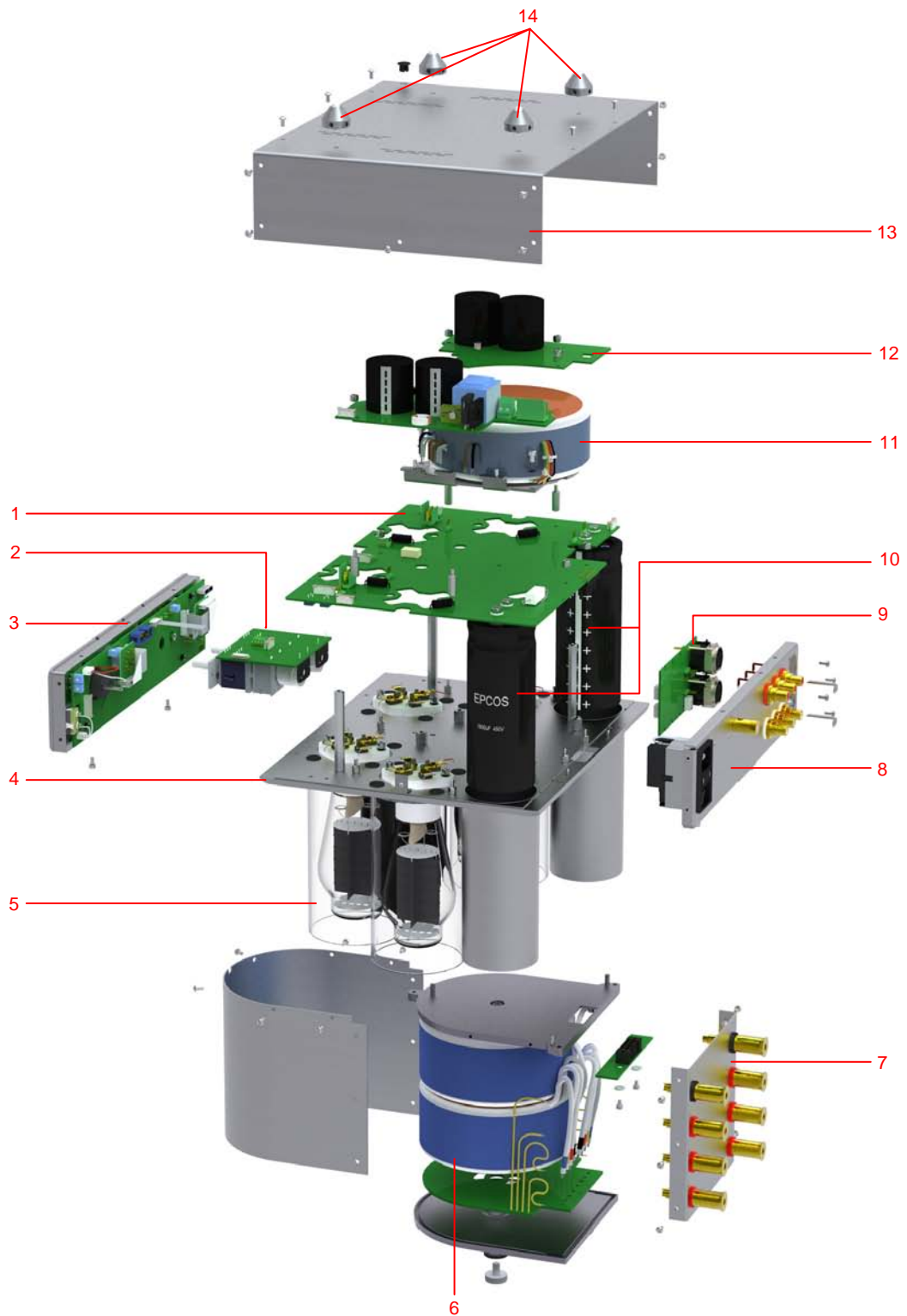
The gain created by the driver stage is 31 dB (2 V input).

#### Power stage

Extremely simple, the power stage only has a few components around the 300B tubes mounted in a push-pull configuration. Essentially, the resistors for the regulation of the grid polarization (bias), and stage gain control resistors (power resistors on the cathode) and those to measure, by the microprocessor, the voltage and current.

The 400 V applied to the anode of the tubes is filtered by an imposing 1'800 $\mu$ F capacitor for each pair. These capacitances are mounted at the base of the tubes on the main motherboard and are placed in cylinders visible on the top of the unit behind the tubes.

The filaments are driven with a continuous 54 V supply stabilized and filtered for each tube by a 56'000  $\mu$ F capacitor.



1. Motherboard: amplification circuits 2. Volume and balance control circuit 3. Front panel, with control and security circuit 4. Solid aluminium top panel 5. Pyrex tube protections 6. Output transformer module. 7. Screw terminals for loudspeaker connections 8. Rear panel with input connectors ground terminal and power module 9. Input circuit 10. Anode filtering capacitors 11. Power transformer 12. Power circuits (2x) with the 4 filament filtering capacitors 13. Lower housing in aluminium 14. Conic feet with Delrin resin Arcap points

### 3.4 Output transformers

These output transformers (one per channel) play a primary role in the final quality of a tube based electronic design, because they match between the power stage (high impedance, several k $\Omega$ ) and the connected loudspeakers (low impedance of a few  $\Omega$ ). They thus determine the power handling over the largest possible bandwidth with the lowest possible distortion.

To obtain output transformers that are precisely matched to the electronics, Nagra designs and winds these components in their own laboratory. The company is one of the only manufacturers in the world with the necessary expertise, as they are delicate items to calculate and technically challenging to manufacture.

The two output transformers of the 300i and 300p amplifiers are carefully dimensioned. They weigh 4 kg each (8.8 pounds). Relieved of air gaps and fitted with a complex winding, they offer exemplary performance under all conditions, including very low frequencies. They are housed in a semi-cylindrical module connected to the top of the unit. This module ensures the insulation of the transformers, and can be easily removed to facilitate transportation. Three impedance levels of 4, 8 and 16  $\Omega$  are available on the gold plated connection posts.

### 3.5 Security and control circuit

Mounted on the rear of the front panel, the control circuit uses a microprocessor that drives the control functions of the amplifier, handles circuit surveillance and security when necessary.

This circuit handles the soft start of the unit, so as to not generate a spike on the supply and to avoid applying the high voltages to cold tubes, that causes premature ageing of the components. After a delay of about 20 seconds, once all the necessary voltages are established, and initial diagnostic is made to check for any anomaly. It also ensures that the tubes are in place, that they are not defective or mis-aligned, and that all the electronics are operating correctly. If not then the amplifier is switched off.

It continues surveillance of the unit throughout its use, measuring any voltage differentials or variations of current to the tubes. It also detects a short-circuit or output overload.

Finally, it handles the source selection, muting of the amplification stages and drives the power dissipation meter as well as the indication of the correct current adjustments and polarization of each tube.

### 3.6 Power supply

The different elements of the power supply – two printed circuits and the power transformer – are assembled on a metal plate fixed below the amplification stage motherboard. This layout reduces the link between the different sections to a minimum.

The powering circuits form a complex assembly, as they need to supply many different voltages for the different sections of the amplifier.

Two transformers are used. The first, a small ultra low consumption (less than 1 Watt) unit mounted on one of the printed circuits, serves solely to run the security system explained in point 3.5. The second transformer (Power transformer) is, like the output transformers, perfectly dimensioned and wound by Nagra. It offers an excellent coupling coefficient, negligible loss and pushes the saturation level to extremes. It is also perfectly silent in operation.



This transformer has 14 secondary windings. One is dedicated to the filament heating for each of the four tubes. The balancing, filtering, voltage stabilisations are entirely managed on the powering module in such a way that any disturbance will not affect the upstream circuits.

The AC connection on the rear panel has an RFI filter to remove high frequency parasites coming from the mains.

## 4. MECHANICAL DESCRIPTION

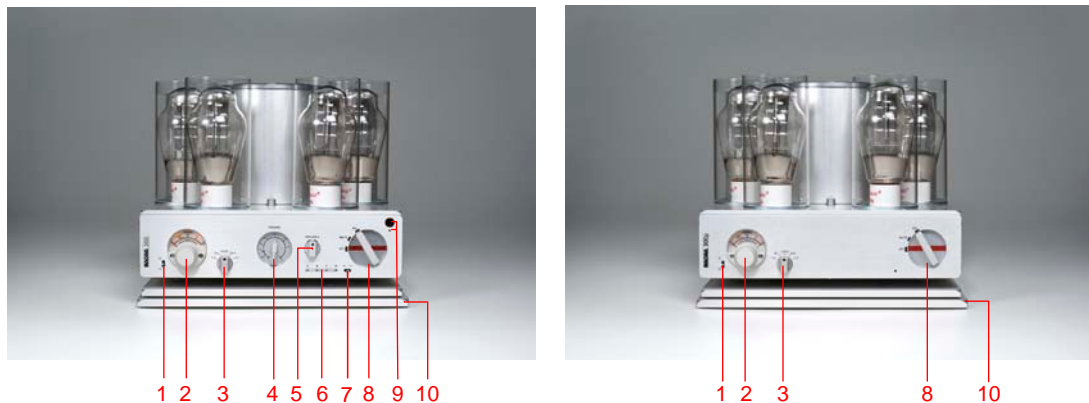
### 4.1 Case

Manufactured from finely brushed anodized aluminium, the box of the 300i and 300p amplifiers matches the aspect and aesthetic characteristics of the brand. The base of the unit has the same dimensions as the other links in the system such as the PL-L, PL-P and VPS preamplifiers as well as the family of CD units. The width and depth are identical (W x D 275 x 230 mm without connectors).

The four triodes mounted on the top of the unit are protected by a Pyrex sleeve avoiding contact with the hot tube. A practical opening next to each tube gives access to the polarization potentiometer.

The 10 mm thick front panel is machined from a solid block, the cover and rear panels are from formed aluminium.

### 4.2 Front panel



#### Integrated Nagra 300i

On the right of the front panel, the unit has a large main rotary switch (8) typical to the brand, used to switch on the unit and to mute the power amplification stages. Next to this switch is the infra-red reception window (9) and yellow LED for the remote control.

In the centre, the front panel is equipped with a volume control (4) and balance (5) and through a switch the source selection (7) with four indication LEDs (6). These LEDs also serve to indicate an anomaly; the LED of input A, B or C flashes respectively depending on the particular problem detected.

On the left side is the Nagra modulometer (2) which has three distinct functions:

- to indicate the power supplied by the amplifier;
- to indicate the impedance match between the amplifier and the loudspeakers depending on the choice of connection posts on the transformer;
- to indicate the polarization adjustments for the tubes.

A five positions switch (3) to the bottom right of the modulometer allows selection of the different functions. On the other side a switch (1) is used to illuminate the unit.

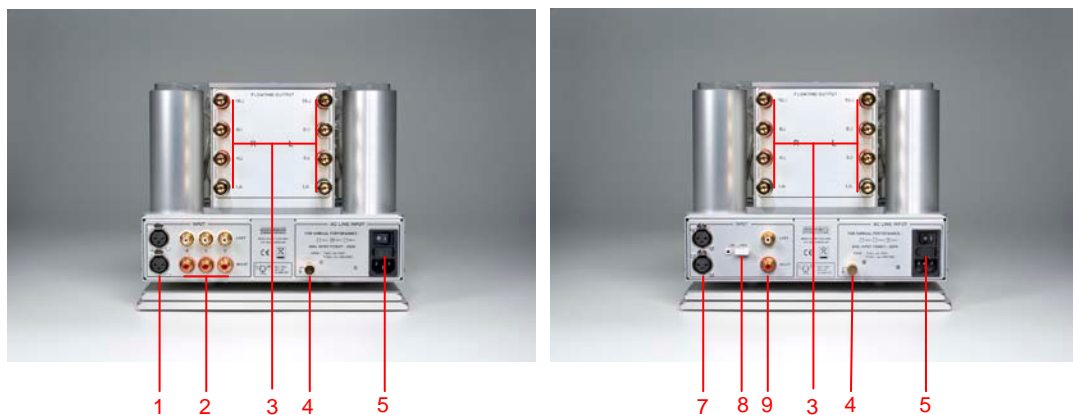
#### Nagra 300p amplifier

Relieved of the pre-amplification section, the amplifier has no volume and balance, nor source selection controls.

In contrast to the integrated amplifier, indication of any anomaly is made through a red LED.

Otherwise the description of the two amplifiers is identical.

#### **4.3 Rear Panel**



#### Integrated Nagra 300i

Fitted on the rear panel, the mains switch, the fuse holder and the IEC connection for the power cord are grouped on the module (5) which houses the RFI filter.

The input connections made up of four pairs of source connectors: one on XLR connectors (1) and three on Cinch (2). A gold screw-post for grounding the chassis (4)

On the rear of the transformer module are four pairs of binding posts (3) destined to receive the loudspeaker connections. Each corresponds to a different impedance: 4, 8 and 16 Ohms.

#### Nagra 300p amplifier

The rear panel has two inputs, XLR (6) or Cinch (8) selectable by a jumper (7). Otherwise it corresponds to the description of the 300i.

#### 4.4 Shock absorber plates

The integrated Nagra 300i and the 300p are delivered with a set of vibration absorbing plates Nagra VFS (10).

These solid aluminium plates are fitted with special Alpha-gel<sup>®</sup> feet specially designed to isolate the electronics they support from vibration. They are specially recommended for tube equipment which is more susceptible to such disturbances.

The vibration-absorbing feature is completed by four conical feet fitted to the box itself. These feet are made from Arcap<sup>®</sup> with Delrin<sup>®</sup> resin points which lodge precisely in the machined dips of the upper plate.

## 5. TECHNICAL SPECIFICATIONS

Amplification class	A
Power	2 x 20 watts RMS stereo into 8 Ω
Bandwidth	14 Hz to 56 kHz, +0/-3 dB
Channel separation	> 70 dB
Signal-to-noise ratio	Typically 105 dB (ASA-A weighted)
Input impedance	> 48 kOhms
Security circuit	LED A: Mains voltage incorrect (115V or 230V) LED B: Box open or output transformer removed LED C: Anode current of a tube <15mA or >180mA
Power supply	90-132 V or 180-264 V, 50-60 Hz
Input connections	Nagra 300p, on XLR or Cinch connectors (gold-plated) Nagra 300i, four sources, one on XLR and three on Cinch connectors (all are gold-plated)
Loudspeaker connections	Binding posts (cables up to 4,2 mm; banana; spade lugs 6,35 mm)
Dimensions	277 x 275 x 232 mm (L x P x H); (10,9 x 10,8 x 9,1 inches)
Weight	14 kg (31 lbs), Nagra VFS supports 2,5 kg (5.5 pounds)

Nagra is continually improving its products and technologies; as a result, the above specifications may be modified without notice.