Martin Ledergerber / Emilie Cornet / Erwin Hildbrand

Humidity in Regularly Played Historical Brass Instruments. The Possibilities and Limitations of Preventive Conservation

Abstract Historical brass instruments that are played regularly face a number of risks to their preservation in the long run. Apart from mechanical damage caused by intensive handling and normal wear and tear, one of the major threats is the interior humidity accumulated through and during playing. As far as brass instruments are concerned, no investigations have yet been undertaken to measure the amount of humidity accumulated during playing and its damage potential. With the aid of climate measurements and complementary tests, the effective corrosive impact of regular playing on the interior surfaces of brass instruments was assessed over a period of several months. Based on the insights gained there, potential preventive conservation strategies were evaluated, and maintenance measures suggested that musicians could implement in situ and with ease.

Introduction In the context of historically informed performance practice, musicians increasingly rely on original instruments dating from the period in question. When performing works of early music, original brass instruments are rarely used, for the simple reason that they have become very rare; instead, people rely on modern replicas. But as far as works of the nineteenth and early twentieth centuries are concerned, players like to use original instruments, chiefly because there are still enough original instruments to be found on the market and in musical collections, and because it is deemed justifiable to use them in the context of historically informed performances. To judge whether it is permissible to rely on a certain historical instrument, conservators revert to the assessment procedure developed by Robert Barclay, which relies on the standards "rarity", "fragility" and "state", and offers a valuable decision-making protocol.[1]

Apart from the normal risk of mechanical damage, using historical wind instruments above all involves the danger of humidity accumulating inside the instrument through and during play; this poses a threat to their long-term conservation. The potential damage impact varies greatly, depending on the material. While the humidity fluctuations caused by playing have been investigated as far as woodwind instruments are concerned, this has

1 Robert Barclay: *The Preservation and Use of Historic Musical Instruments. Display Case and Concert Hall*, London 2004, pp. 233–244.

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yet to be done for brass instruments.[2] The present investigation set itself the task of examining the climatic changes caused by playing in order to shed light on the changes to the interior surface textures brought on by moisture in regularly played, historical brass instruments. In addition, our aim was to put forward measures to reduce the risk of humidity-related damage caused by frequent playing. This investigation was conducted in the context of the interdisciplinary research project "Brass instruments of the 19th and early 20th centuries between long-term conservation and use in historically informed performance practice", funded by the Swiss National Science Foundation.[3] Brass instruments dating from the nineteenth and early twentieth centuries were lent to musicians with the intention that they should play them regularly over a period of several months. At the end of the project, a performance of Igor Stravinsky's original, 1913 version of *Le Sacre du Printemps* was scheduled. The instruments under examination came from private and public collections whose collection concepts explicitly made provision for playing their instruments.

In the context of this project, the Conservation Department of the Swiss National Museum was given the task of assessing possible approaches to preventive conservation and of coming up with easily implementable maintenance measures that the musicians could apply regularly over an extended period of time. The measures proposed thus had to be viable outside a normal conservatory setting and generally accessible, primarily to musicians who do not necessarily have in-depth specialist knowledge of conservation. In other words, these measures had to be different from the procedures normally utilised by conservators in a laboratory setting.

Brass is an alloy of copper (Cu) and zinc (Zn).[4] From a conservation perspective, instruments made of this material are regarded as being not particularly problematic. This is because brass is a stable material when kept in a dry, pollutant-free environment.[5] The investigations in this study were restricted to damage occurring inside brass instruments through regular playing. There is a comprehensive literature on the changes and damage to the outer surfaces of brass instruments that are played regularly, and on the

2 Ilona Stein: Blasfeuchte in Holzblasinstrumenten, in: *Studien zur Erhaltung von Musikinstrumenten. 1: Holzblasinstrumente, Firnisse*, ed. by Friedemann Hellwig, München 2004 (Kölner Beiträge zur Restaurierung und Konservierung von Kunst- und Kulturgut, Vol. 16), pp. 9–121.

3 See www.hkb-interpretation.ch/projekte/korrosion (all links in this article last consulted 18 October 2022).

4 Hannes W. Vereecke/Bernadette Frühmann/Manfred Schreiner: The Chemical Composition of Brass in Nuremberg Trombones of the Sixteenth Century, in: *Historic Brass Society Journal* 24 (2012), pp. 61–75.

5 Lyndsie Selwyn: *Metals and Corrosion. A Handbook for the Conservation Professional*, Ottawa 2004, pp. 62–71.

problems stemming from normal wear and tear. Robert Barclay makes frequent reference to various conservatory concerns caused by regular playing.[6] For an overview of the range of possible damage to brass instruments, see Panagiotis Poulopoulos and Arnold Myers.[7]

Preventive conservation method The aim of preventive conservation is to avoid, or at least reduce as best as possible, the risks involved during the storage and use of cultural items, in order to ensure their long-term preservation. This requires proactively identifying potential risks and damage to both individual objects and entire collections, and taking measures to protect these items from harm. A successful preventive conservation strategy will thus entail registering and understanding an object in terms of its materiality and present condition, while at the same time recognising all the risks and damage factors that an object or group of objects could be subject to in a specific usage context. Playing brass instruments regularly comes with a multitude of risks. In contrast to displaying instruments in an exhibition or holding them in storage, these playing risks are often difficult to determine and assess.

Since we are well aware of the many risks that come with lending out and playing instruments over a period of several months, we relied on a wide range of preventive approaches. First and foremost in this respect, we wanted to raise the users' awareness about the concept and aims of preventive conservation. After carefully selecting the musicians, and before handing them their instruments, they were instructed about the basics of preventive conservation and asked to handle the instruments carefully and ensure their correct maintenance. The terms of use and the maintenance instructions were given in writing (see Appendix). The products to be used were specified, as were the measures required for the correct maintenance of the tuning slides and valves. During the entire project, the musicians were supported and monitored by a trained conservator. Halfway through the project and at its end, the musicians and all the specialists involved in the project met up to compare and discuss the usage and maintenance practices adopted.

Evaluation of products To ensure reliable functioning, the movable parts of the instruments must be treated on a regular basis. The oils and greases applied to the various valves and tuning slides must be absolutely safe in conservation terms, given that they

6 Robert Barclay: *The Preservation and Use of Historic Musical Instruments. Display Case and Concert Hall*, London 2004; and *The Care of Historic Musical Instruments*, ed. by Robert Barclay, Edinburgh 1997.

7 Panagiotis Poulopoulos/Arnold Myers: Investigating and Preventing the Deterioration of Historic Brass Instruments in EUCHMI, in: *Diagnostic and Imaging on Musical Instruments. Selected Proceedings of the 1st and 2nd International Workshop, Ravenna 2010/2011*, ed. by Emanuele Marconi, Florence 2016, pp. 55–58.

come into direct contact with the instrument. Various commercial products were tested as to their stability and chemical inertness. For this purpose, a simple test series was devised in which small plates of different brass alloys were exposed to different oil and grease samples in small, closed glass jars covered with a foil for a period of several months (see Figure 1). The samples were arranged so that a third of each formerly polished and degreased brass plate was submerged in the product to be tested, while the upper two thirds were exposed to its gaseous components. In a second test set-up, brass powder was mixed with the different products in porcelain vessels, and exposed to 120° Celsius in an oven for a period of twenty-four hours. The musicians were subsequently instructed to use those products that had produced no corrosive effect on the samples in the two tests.[8]

Assessment of instrument cases and covers With regard to the transport and storage of the instruments during the project, various instrument cases and covers were discussed and assessed. The problem of keeping instruments in cases and covers made of non-age-resistant materials is known, as these materials often tend to be chemically unstable and emit pollutants.[9] Careful assessment is therefore required, not least because the materials are in direct contact with the instruments and because the concentration of pollutants tends to rise quite quickly within closed cases and covers, and can damage the instruments. The materials used in the cases and covers were systematically assessed by means of an accelerated aging test regarding their stability and chemical inertness.[10] For the project, only such cases and covers were used that the test results showed were suitable for long-term usage.

Climate tests In order to ascertain the climatic conditions in the interior of regularly played brass instruments, temperature and humidity were measured in multiple test series before, midway through, and after playing, with the aid of electronic data loggers (Figure 2). Through sensors measuring merely 6 mm in diameter and connected by cable with the loggers over a distance of up to 100 cm, we were able to measure the climatic conditions within the instruments at different points over an extended period of time.[11] Measuring was carried out in storage spaces under very stable climatic conditions (T 18–20 °C, 50 % RH); the room climate was recorded as a reference value.

8 The key oils and tuning slide greases selected were La Tromba Cork Grease, Denis Wick Advanced Formula Valve Oil with PTFE, Hetman Synthetic Lubricant 17 Key Oil MEDIUM KEY, and Hetman Tuning Slide Grease 8 TSG.

9 See Klaus Martius/Markus Raquet: Instrumentenkästen. Schutz und Sicherheit?, in: VDR Beiträge zur Erhaltung von Kunst- und Kulturgut 2005/1, pp. 123–128.

10 See Lorna R. Lee/David Thickett: Selection of Materials for the Storage or Display of Museum Objects, London 1996 (British Museum Occasional Papers, Vol. 111).

11 MSR145 data logger with humidity (RH) and temperature (t) sensor, working between -20 and +65 °C

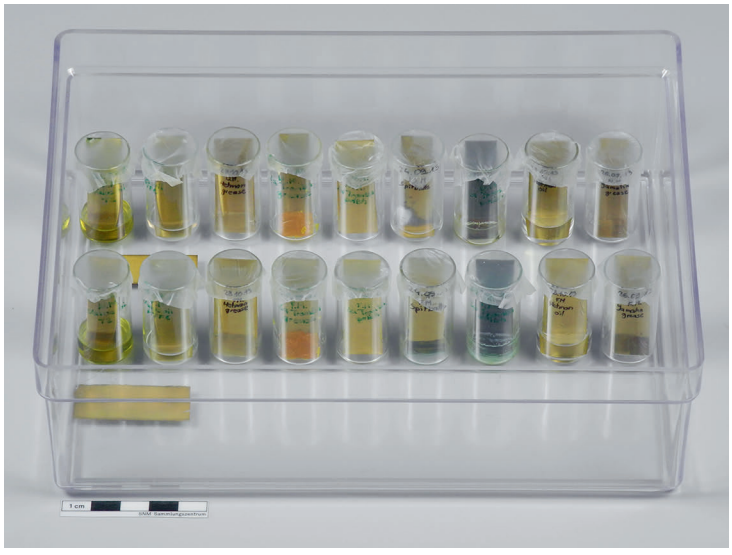

Figure 1 Test set-up using small brass plates to assess the corrosiveness of different oils and greases

Figure 2 Test arrangement using data loggers for climate testing on a trumpet

In a first phase, we tested the interior climatic changes generated by playing on modern brass instruments. Then, after determining the test parameters, we carried out systematic climate measurements on all 16 instruments involved in the project (5 trumpets, 8 horns, 1 trombone, 1 Wagner tuba, 1 tuba). Relying on a wide scope of instruments ensured that the insights gained were valid for different instrument types featuring varying tube lengths and diameters, and thus diverse forms and volumes.

The test series showed that the climatic effects caused by playing are comparable for all instrument types we examined.[12] Figure 3 shows a typical curve progression during playing. Within the first minutes of playing, the humidity scores within the instruments

and between 0 and 100 % relative humidity, with an accuracy of ±2 % (MSR Electronics GmbH, Mettlenstrasse 6, 8472 Seuzach, Switzerland, www.msr.ch).

12 Emilie Cornet: *Approches pour la conservation préventive des instruments de musique en cuivre de la collection Burri à Berne*, unpublished report, Swiss National Museum, Affoltern am Albis 2013, pp. 6–9.

rise to over 90 % of relative humidity (RH). The moisture-saturated air condenses on the inside walls, forming droplets and local patches of water, to the effect that the relative humidity values remain exceedingly high over several days. Even when the valve and tuning slides are emptied after use and left out to dry, relative humidity within the instruments does not recede below 70 % RH within 24 hours. One surprising finding was that, even after the maximum recording period of 20 days, relative humidity within the instruments did not recede below 60 % RH (Figure 4).

As far as the temperature is concerned, the tests showed that the temperature rises moderately during playing as expected, owing to the musician's body and breath temperatures. However, these temperature changes due to playing present no problem for the preservation of the instruments.

Methods of drying The high humidity, far above the values measured for the ambient air, suggests that corrosion within the instruments is highly probable. From a conservation perspective, our first priority must be to dry the instruments rapidly after use in order to avoid corrosion damage. The use of moisture absorbers, solvents, heated air and compressed air was tested, but the special project requirements meant that these were deemed inappropriate, since they could not be applied by the musicians independently, on a daily basis, and in separate locations. However, active drying with the help of fans meets all requirements; it is easy and poses no risk to either the instrument or the musician. Climate tests have shown that the use of fans is a highly efficient drying method.[13]

For this project, we used fans especially designed for drying instruments that were powered through a USB port (Figure 5)[14] next to commercial mini-fans. After playing, the tuning slides and valves were emptied and then reinserted. With the help of Velcro straps, the valves were fixed in a position in which all slides were open, allowing an unhindered airflow through all parts of the instrument. Then the fan was attached to the leadpipe (horns: two fans, one to the crook, one to the bell) and turned on. Complete drying was achieved through the continuous stream of air, so that values matching the ambient climate were reached within a matter of 1.5 to 3 hours at most. This marks the end of the drying process.

Figure 6 shows the typical process of active drying with the help of a fan. In this specific case, a humidity sensor was placed 40 cm away from the bell, and a second sensor

13 See also the three videos, produced in the project by the Paul Scherrer Institute (PSI), making visible the humidity in a cornet: https://youtube.com/playlist?list=PL5J-BZoNMhGKj5-u_KKuy7lIKGuFcL2bo.

14 Produced by Stephan Berger, CH-2336 Les Bois (www.serpents.ch).

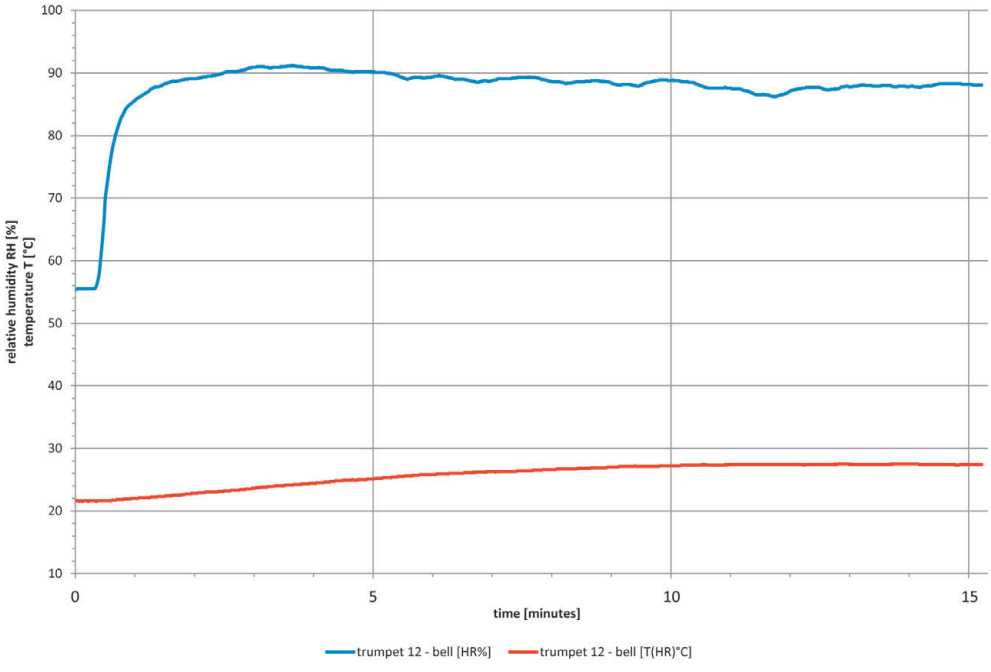

Figure 3 Typical climate diagram showing the changes to relative humidity (RH) and temperature (T) during the use of a brass instrument over a period of 15 minutes

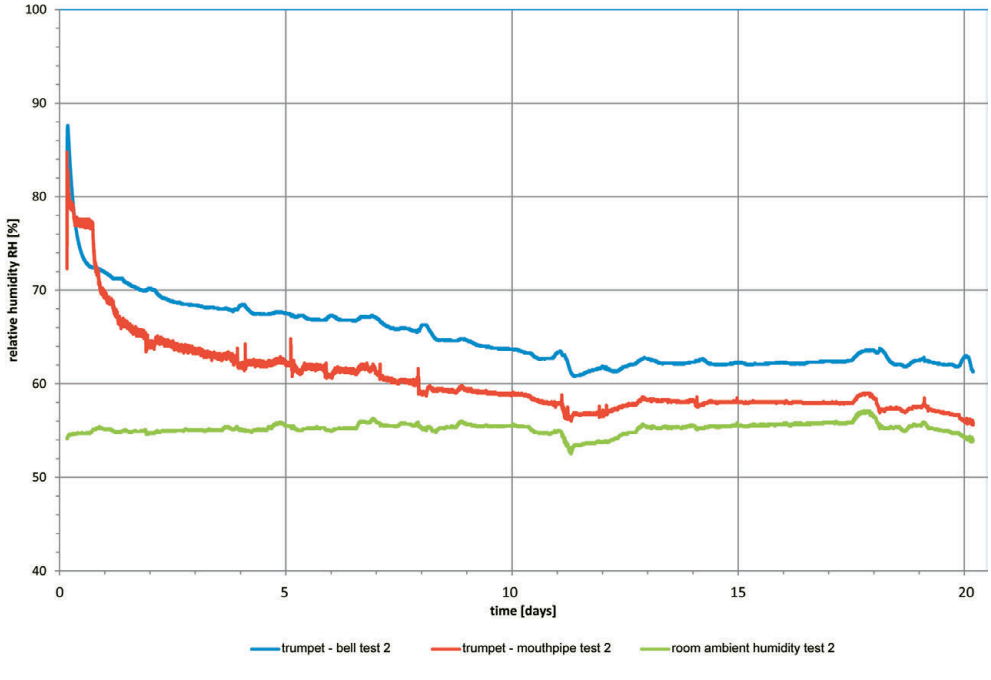

Figure 4 Typical climate diagram showing the changes to relative humidity (RH) at two separate points within a brass instrument over a period of 20 days if the instrument is not specially treated and simply left to air dry. The green curve indicating the relative humidity of the ambient air

Figure 5 Fans used to dry the instruments efficiently

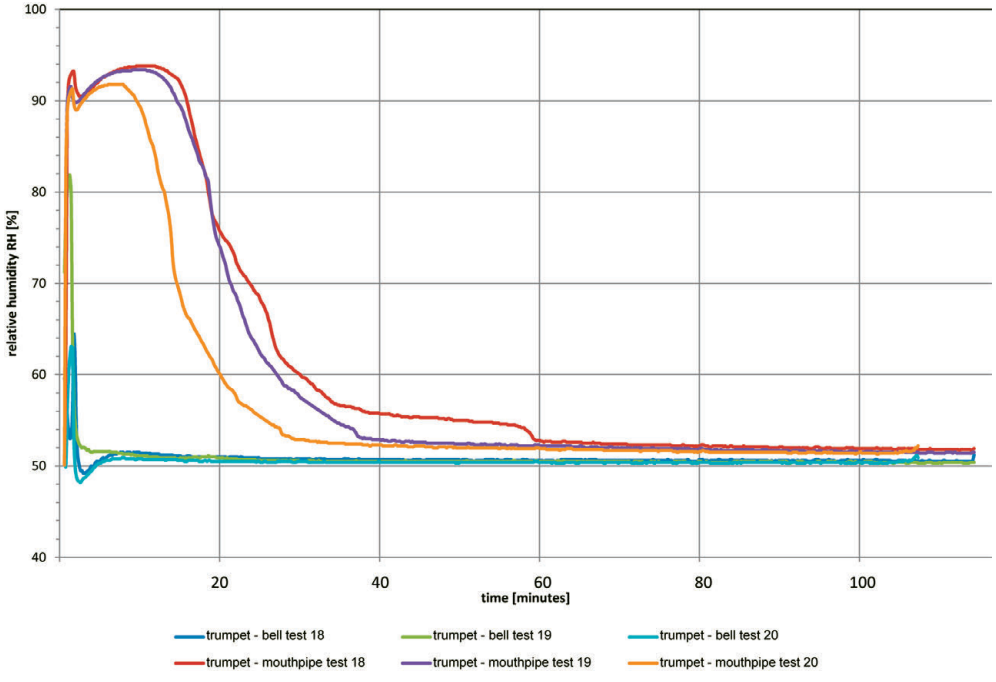

Figure 6 Typical climate diagram showing the decrease of relative humidity over time inside a trumpet in different places, using a fan as a drying device

inside the mouthpipe, 20 cm away from the opening. The diagram shows three measurement sequences, with all three producing very similar results. The area around the bell was dry within a few minutes, the section within the narrow mouthpipe after roughly 60 minutes.

In order to test the efficacy of the preventive care measures proposed, two groups were defined for the subsequent period of playing. In the first group, the musicians treated the instruments according to the newly developed maintenance concept, relying on active drying for at least ninety minutes after each period of playing as a prime measure. The instruments of the second group served as a control; here the musicians treated them in the habitual way, that is, the tuning slides and valves were merely emptied and put out to dry after use, without reverting to active drying.

According to the research set-up, the musicians of both groups were asked to play their instruments over a period of 14 months for at least 5 minutes a day. In order to correlate any changes found in the instruments according to the mode and duration of playing, the musicians were also asked to keep a written protocol specifying the playing duration each day, and the care measures applied. On average, the instruments were played 275 times for 6.19 minutes, resulting in an average playing time of 28.3 hours. Three testing methods (electrochemistry, neutron tomography and endoscopy) were applied before the start of the project, after 7 months, and at the end of the fourteen-month period, to ascertain whether the instruments had undergone any changes and to assess the effectiveness of the preventive conservation measures.[15]

Findings and discussion The regular use of historical brass instruments is hardly compatible with the aims of long-term conservation. However, in the context of historically informed performance practice, the use of certain instruments from collections with a corresponding utilisation concept is acceptable. In such cases, even more attention should be given to preventive conservation measures, considering the aims of long-term preservation.

The climate tests we conducted provided clear evidence that brass instruments played regularly remain permanently humid inside if they are only treated conventionally, but not actively dried. In the instruments tested, the humidity scores remained at over 60 % RH for several days. Under these circumstances, corrosion processes are likely to set in, that is, parts of the basic brass material are transformed into corrosion products, leading to a loss of original substance. Active drying with the aid of fans that provide a

15 See the articles by David Mannes/Eberhard Lehmann (pp. 83–91); Bernhard Elsener/Tiziana Lombardo/Federica Cocco/Marzia Fantauzzi/Marie Wörle/Antonella Rossi (pp. 61–72) and Martin Ledergerber (pp. 92–96) in this volume.

flow of air inside the instrument and evacuate the humidity is a highly efficient, easy-to-implement method of drying. The humidity scores in the different types of instruments tested were reduced to values matching the ambient climate within a matter of hours, thus significantly reducing the risk of corrosion. Based on the findings of this study, we would certainly advise musicians to use fans for drying their brass instruments. After the period of play, and before the instrument is returned to storage, further conservation treatments are required. These, however, should be conducted by a qualified conservator.[16]

Apart from active drying as a measure of preventive conservation against corrosive humidity, the use of corrosion inhibitors, chemical passivation or the application of a protective coating inside regularly played period brass instruments are further possible damage-avoiding strategies. However, these approaches were not further pursued in this study, as it would have meant making irreversible changes to areas within the instrument that are difficult to access. Moreover, the efficacy of such measures over time can only be tested to a limited extent. Last but not least, the effect on the acoustic quality of deposits and overlays inside brass instruments needs further investigation.[17]

Although the focus of this study was primarily on the prevention of humidity-related damage inside brass instruments, the protection of the instruments' outside metal surfaces was also an aspect of the preventive conservation measures. Despite daily use and handling, corrosion damage and stains to the instruments' outer surface caused by sweaty hands were largely avoided, as the musicians were asked to wear gloves. All in all, sensitising the participating musicians to the goals of preventive conservation was key to the project's success. By fully and correctly adhering to the maintenance protocol, mechanical damage was avoided almost completely, despite the long, intensive period of use.

16 See Marie-Anne Loeper-Attia: L'impact des restaurations sur la conservation des instruments de musique de la famille des cuivres, in: *Paris – un laboratoire d'idées. Facture et répertoire des cuivres entre 1840 et 1930. Actes du colloque*, Paris 2010, pp. 58–69, here p. 69.

17 John P. Chick/Murray D. Campbell/Arnold Myers: *The effects of the internal condition of the bore on the acoustic properties of brass instruments*. Paper presented at Musical Acoustics Network Summer Meeting, Edinburgh, July 2009.

APPENDIX Terms of use and the maintenance instructions

HKB HEAB BUA
Hochschule der Künste Bern
Haute école des arts de Berne
Bern University of the Arts

Merkblatt zur Handhabung von historischen Blechblasinstrumenten

Das Instrument ist mit grosser Sorgfalt zu behandeln, das Handling ist auf ein Minimum zu beschränken und nur Projektmitarbeitern gestattet.

Ein historisches Instrument ist immer mit Handschuhen zu spielen (Baumwolle, besser geeignet sind Nitril- oder Latexhandschuhe).

Nach jedem Bespielen in allen Stimmzügen und im Korpus das Kondenswasser entleeren.

Pistons regelmässig ölen, allerdings nach Möglichkeit nicht aufschrauben, sondern Öl nur durch Pistonstimmzüge eintropfen lassen. Zum Unterhalt und zur Pflege sind ausschliesslich die von der HKB abgegebenen Produkte zu verwenden.

Bei längerem Nicht-Bespielen des Instrumentes alle Stimmzüge entfernen und an einem sicheren Ort offen lagern. Ablageflächen sollen sauber und gepolstert sein.

Es dürfen keine Veränderungen am Instrument vorgenommen werden.
Bei entstandenen Schäden immer den verantwortlichen Restaurator (Martin Mürner) benachrichtigen und Reparaturen nur durch ihn ausführen lassen.

Transporte nur im zugehörigen Instrumentenkoffer.

Beim Verlust des Instrumentes oder bei irreparablen Schäden ist grundsätzlich die Privathaftpflichtversicherung des Bläsers verantwortlich. Bei Nichtverschulden des Bläsers übernimmt das Projekt einen allfälligen Selbstbehalt.

Jedem Instrument ist ein persönliches Bespielungskonzept zugeordnet, das dieses Merkblatt ergänzt.

Martin Mürner HKB
Verantwortlicher Restaurator

FH Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

Sammlungszentrum.

SNF-Projekt _Korrosion an gespielten Blechblasinstrumenten CR12I1_146330 / 1
"Brass instruments of the 19th and early 20th centuries between long-term conservation and use in historically informed performance practice"

Bespielungskonzept

- tägliche Bespielung, Spieldauer mindestens 5 Minuten
- Entleeren und übliche Pflege nach jedem Bespielen (Gruppe A und B)
- Gruppe A: zusätzliche Trocknung mit Ventilator während mindestens 1.5 Stunden nach jedem Bespielen

Wir bitten Sie das Protokoll unmittelbar nach dem Bespielen auszufüllen und folgende Richtlinien einzuhalten:
Grösste Sorgfalt im Umgang mit den historischen Musikinstrumenten, Handschuhe tragen, nur die im Rahmen des Projektes getesteten und von Martin Mürner vorgegebenen Pflegemittel verwenden (Öl: Denis Wick Advanced Formula Valve Oil With PTFE, Fett: La Tromba Cork Grease)

Inv.Nr	Instrumente	Jahrgang	Gruppe	Pflegemassnahmen	erweitertes Pflegekonzept
B1134.	Trompete	1900-1930	B	Entleeren der Stimmzüge, übliche Pflege	
B392./556	Trompete	1900-1920	A	Entleeren der Stimmzüge, übliche Pflege	Trocknung mit Ventilator
B391./189	Trompete	1930-1940	B	Entleeren der Stimmzüge, übliche Pflege	
HKB 5027	Trompete	2012	A	Entleeren der Stimmzüge, übliche Pflege	Trocknung mit Ventilator
B088.	Trompete	1869	B	Entleeren der Stimmzüge, übliche Pflege	
B116./116	Horn	1930	A	Entleeren der Stimmzüge, übliche Pflege	Trocknung mit Ventilator
HKB5004	Horn	1922	B	Entleeren der Stimmzüge, übliche Pflege	
HKB5024	Horn	1932	A	Entleeren der Stimmzüge, übliche Pflege	Trocknung mit Ventilator
HKB5009	Horn	1900	B	Entleeren der Stimmzüge, übliche Pflege	
HKB5005	Horn	1920-30	A	Entleeren der Stimmzüge, übliche Pflege	Trocknung mit Ventilator
HKB5017	Horn	1900	B	Entleeren der Stimmzüge, übliche Pflege	
HKB5025	Horn	1910	A	Entleeren der Stimmzüge, übliche Pflege	Trocknung mit Ventilator
B098./761	Horn	1900	B	Entleeren der Stimmzüge, übliche Pflege	
HKB5020	Posaune	1902	A	Entleeren der Stimmzüge, übliche Pflege	Trocknung mit Ventilator
B1414./974	Wagnertuba	1936	B	Entleeren der Stimmzüge, übliche Pflege	
K236	Tuba	1920	A	Entleeren der Stimmzüge, übliche Pflege	Trocknung mit Ventilator

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SNF-Projekt _Korrosion an gespielten Blechblasinstrumenten CR12I1_146330 / 1
"Brass instruments of the 19th and early 20th centuries between long-term conservation and use in historically informed performance practice"

Bespielungsprotokoll

Instrument Nr.	_____
Name Musiker	_____
Gruppe	_____

Spieldauer **mindestens 5Minuten**
Entleeren und normale Pflege immer (Gruppe A und B)
Zusätzliche Trocknung mit Ventilator (Gruppe A) **mindestens 1.5 Stunden**
Öl: Denis Wick Advanced Formula Valve Oil With PTFE
Fett: La Tromba Cork Grease
Handschuhe tragen

Datum	Spieldauer	Entleeren	Ventilator	Bemerkungen

Schweizerisches Nationalmuseum. | Sammlungszentrum. | Lindenmoosstrasse 1, 8910 Affoltern am Albis |
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Content

To Play or Not to Play

Corrosion of Historic Brass Instruments

Romantic Brass Symposium 4 • Edited by Adrian von Steiger, Daniel Allenbach and Martin Skamletz

Musikforschung der
Hochschule der Künste Bern
Edited by Martin Skamletz
and Thomas Gartmann
Volume 15

Dieses Buch ist in gedruckter Form im Januar 2023 in erster Auflage in der Edition Argus in Schliengen/Markgräflerland erschienen. Gestaltet und gesetzt wurde es im Verlag aus der *Seria* und der *SeriaSans*, die von Martin Majoor im Jahre 2000 gezeichnet wurden. Gedruckt wurde es auf Eos, einem holzfreien, säurefreien, chlorfreien und alterungsbeständigen Werkdruckpapier der Papierfabrik Salzer im niederösterreichischen Sankt Pölten. Das Vorsatzpapier *Caribic cherry* wurde von Igepa in Hamburg geliefert. *Rives Tradition*, ein Recyclingpapier mit leichter Filznarbung, das für den Bezug des Umschlags verwendet wurde, stellt die Papierfabrik Arjo Wiggins in Issy-les-Moulineaux bei Paris her. Das Kapitalband mit rotschwarzer Raupe lieferte die Firma Dr. Günther Kast aus Sonthofen im Oberallgäu, die auf technische Gewebe und Spezialfasererzeugnisse spezialisiert ist. Gedruckt und gebunden wurde das Buch von der Firma Bookstation im bayerischen Anzing. Im Internet finden Sie Informationen über das gesamte Verlagsprogramm unter www.editionargus.de, zum Institut Interpretation der Hochschule der Künste Bern unter www.hkb.bfh.ch/interpretation und www.hkb-interpretation.ch. Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über www.dnb.de abrufbar. © der zeitgleich erschienenen digitalen Version: die Autorinnen und Autoren, 2023. Dieses Werk ist lizenziert unter einer Creative Commons Namensnennung-Nicht kommerziell 4.0 International Lizenz (CC BY-NC 4.0).
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