Köln Bonn Airport

Aircraft De-Icing Manual

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1. Foreword

This Aircraft De-Icing Manual describes the principles of the de-icing operation of Cologne Bonn Airport (Flughafen Köln Bonn, FKB) and gives necessary information for our clients. The contents are limited to general topics as well as applying procedures at Cologne Bonn Airport, vehicle fleet and personnel structures. This manual therefore mainly aims at employees involved in aircraft de-icing of all airlines serving Cologne Bonn Airport or using it as a diversion airport and need data for their planning.

All described procedures and measures are based on the guidelines and recommendations of the International Civil Aviation Organization (ICAO), the European Aviation Safety Agency (EASA) and the International Air Transport Association (IATA), the Society of Automotive Engineers (SAE) as well as their successor organizations and sub-organizations. Furthermore, the Airport User Regulations (Flughafenbenutzungsordnung, FBO) apply as well as the deductive measures from the Aerodrome Manual (Flugplatzhandbuch), section 2.2. "Safety Management System" (SMS) of Cologne Bonn Airport. All those for whom this manual forms the basis of the de-icing operation are responsible for the implementation of and compliance with all safety regulations applicable.

The references of this manual relate exclusively to general standards, directives and requirements. It includes information from requirements set by vehicle, aircraft or de-icing fluid manufacturers in the versions known to the Cologne Bonn Airport. The training content and the services offered exclusively relate to commercial aircraft. Rotorcraft and military aircraft as well as the entire private aviation are not sufficiently accounted for thereby.

The training type and its content meet the standards and quality attributes of the Society of Automotive Engineers (SAE). They include de-icing procedures, strategies and techniques, as well as operation of de-icing vehicles.

The term "de-icing" always relates to the two sub-processes of "de-icing" and "anti-icing". In principle, the de-icing season is considered to be 01.10. to 30.04. inclusive of the subsequent year.

In all measures and workflows, the safety of the persons involved, the vehicles and the aircraft always has first priority. The principles of "Safety First" and the "Clean Aeroplane Concept" apply. An aircraft is regarded as free of contamination only once all critical surfaces have been completely cleaned. A surface is only considered protected against re-icing if the required ADF minimum quantity per SAE standard has been applied specifically to the aircraft type.

The content of this manual is based on these principles. Compromises will not be made in any of these points.

Safety always takes priority over economic aspects!

Aircraft de-icing is an important safety aspect in aviation, demands high quality aspirations and requires an up-to-date training status of all involved.
All questions that may occur can be directed to the Head of De-Icing operations who is available at any time.

2. Responsibilities

As from season 2018/2019, Ground Services of Köln /Bonn GmbH is responsible for the aircraft de-icing and ensures that aircraft de-icing in terms of planning, organization, training and technical equipment meets all the requirements and aspirations of ICAO, EASA, IATA, SAE and manuals of airlines FKB provides services for.

2.1. Coordination Winter Services, Aircraft De-Icing

- Management, planning und organization of aircraft de-icing
- Planning of training on aircraft de-icing in theory and practice
- Preparation and review of all documents
- Archiving all documents and records
- Review and control of the individual processes for aircraft de-icing
- Securing the functionality and operatively of the de-icing vehicles
- Development of de-icing strategies for aircraft de-icing
- Preparation of the data for billing de-icing transactions
- Support for internal and external audits
- Securing the standards based on international and local regulations
- Performing laboratory tests of the individual fluids before the season and on demand

2.2. Aircraft De-Icing Training

- Schedule planning for the training for aircraft de-icing in theory and practice
- Preparation of all training documents
- Execution of aircraft de-icing training
- Administration of written exams and practical tests
- Clearance of trained operators for de-icing operation
- Constant development of training processes

3. Applicable Documents

- ICAO Doc 9640 (Manual of Aircraft Ground De-Icing/Anti-Icing Operations)
- IATA SGHA (Standard Ground Handling Agreement)
- SAE AS 6285D (Aircraft Ground De-Icing/Anti-Icing Processes)
- SAE AS 6286B (Training and Qualification Program for De-Icing/Anti-Icing of Aircraft on the Ground)
- SAE AS 6332 (Quality Assurance Program for De-Icing/Anti-Icing of Aircraft on the Ground)
- SAE ARP 6257 (Aircraft Ground De-Icing/Anti-Icing Communication Phraseology for Flight and Ground Crews)
- SAE ARP 1971D (Aircraft De-Icing Vehicle - Self-Propelled)
- SAE AMS 1424/1 (De-Icing/Anti-Icing Fluid, Aircraft, SAE Type I)
- SAE AMS 1428/1 (Fluid, Aircraft De-Icing/Anti-Icing, Non-Newtonian SAE Types II, III, and IV)
- Process Manual Winter Services of Flughafen Köln/Bonn GmbH
- Airport User Regulations (Flughafenbenutzungsordnung, FBO) of the Flughafen Köln Bonn GmbH
- Aerodrome Manual of the Flughafen Köln Bonn GmbH
- General Terms and Conditions for Aircraft De-Icing (AGB-Enteisung) of the Flughafen Köln Bonn GmbH

4. Background and Causes

So-called "icing-up" is the process of formation of contamination under freezing conditions. This contamination on the so-called critical aircraft components results in deterioration up to total loss of the aerodynamic flows. In addition, it can result in loss of controllability through icing of the control surfaces; all maximum weight limits can be exceeded. This issue has been the second most common cause of accidents in aviation in the last 30 years.

Summarized, in aircraft de-icing three main causes are mentioned that can result in damage or accidents through icing.

- **Technical Faults**
  - → Quality defects of the fluid or de-icing equipment
  - → Defect mixing systems in facilities and vehicles
- **Organizational Errors**
  - → No timely preparation of winter services
- **Human Factor**
  - → Deficient training of de-icing personnel
  - → Deficient training of flight personnel
  - → False estimation of own capabilities and performance
  - → Lack of ability to accept criticism
  - → Poor or confusing communication
  - → Improper performance of de-icing
  - → False or neglected checks
  - → Misinterpretation of tables, safety provisions and instructions

This shows that most of the causes reflect the so-called human factor. Therefore, it is our constant endeavour to counteract all the above causes through qualification, organization and motivation.

Therefore, it is very important that the airport operator, respectively the de-icing service provider, as well as the airlines have both sufficient professional competence and conviction to first determine the necessity of a de-icing and then to choose and apply the appropriate de-icing procedure and de-icing fluid.

The responsibility and the decision as to whether and when de-icing is necessary is always with the pilots in command. The de-icing operator is always responsible for performing the de-icing and the final check PDAC[1]. The de-icing operator therefore decides if de-icing by the FKB can be performed or not if the pilot chooses a wrong de-icing fluid or instructs a wrong de-icing method.

5. Aircraft De-Icing Personnel

Except for the Head of De-Icing Operation and the Head of De-Icing Training, all personnel in aircraft de-icing is recruited from the entire workforce of Cologne Bonn Airport and perform these duties in parallel or in addition to their normal operating tasks within the company. This means that all employees have basic to highly advanced knowledge of all operations at the airport, regardless of being further trained as de-icing operators.

[1] Pre-/Post De-Icing/Anti-Icing Check – visual check for contamination before or after de-icing

6. Training and Qualification in Aircraft De-Icing

All employees involved in aircraft de-icing have to attend a training for de-icing operators with the objective to independently plan and perform aircraft de-icing with regard to the environment and the clients. These trainings are based on the guidelines and recommendations of the SAE AS 6286B "Training and Qualification Program for De-Icing/Anti-Icing of Aircraft on the Ground" and are adapted to the local conditions.

However, the most important rule in this context is: Safety first!

As Cologne Bonn Airport has completed its vehicle fleet with de-icing vehicles approved for one-person operation[2] since de-icing season 2016/2017, there will be no separate driver training according to qualification DI-L10 anymore. All participants undergo the training for the de-icing operator and acquire in addition the ability to independently perform the PDAC. Thus, all participants who successfully completed the training are qualified according to SAE qualifications DI-L20 and DI-L30B.

All training records and examination results will be archived.

6.1. De-Icing Operator – SAE Qualification DI-L20

Employees who apply for aircraft de-icing attend a basic training of up to five days. De-Icing Operators, who successfully performed in de-icing in the previous season, have to attend a refresher training. All theoretical training parts are provided equally to all course participants and are completed with a compulsory written exam. Refreshers completes the theoretical training and exams independently on the computer. The exam is successfully passed when at least 80 % of 32 questions have been answered correctly. Regardless of that, the content of questions that have been answered incorrectly will be discussed. The following topics are part of the training:

- Regulations, standards and recommendations
- New processes, new development and alternative technology, experience from previous winters
- Basic knowledge about aircraft performance and aerodynamics
- Effects of contamination on the aircraft performance
- Basic meteorological knowledge and reasons for icing up on aircraft
- Basic features of de-icing fluids, composition and effects
- Instruction into the holdover time tables
- Methods for the removal of contamination and for protection against re-icing
- Safety aspects and no spray areas
- Anti-Icing code and communication procedures in German and English
- Local regulations and restrictions, environmental protection, airport operating procedures and ATC
- Necessary checks and operational quality checks

The practical training starts with exercises on de-icing simulators, which are exactly modelled on the operator cabins of our de-icing vehicles. The simulator training comprises:

- Instruction in the units of the de-icing vehicle cabin of both vehicle types
- Instruction in the Data Transfer System (DTS).
- Principles of vehicle operation in the one-person operation
- Principles of spraying techniques on different aircraft types
- Principles of communication and workflows when using more than one vehicle

[2] Technically, the vehicles can also be used in a two-person operation.

Subsequently, the training on the de-icing vehicles is carried out, including the following subjects:

- Instruction in the different vehicle types
- Checks of the vehicle condition and filling level of all relevant and necessary tank facilities
- Processes for emergency operation
- Driving training, admissible / prohibited driving routes
- Operation of tank facilities A and D
- Filling of the vehicles with water, Type I and Type II.
- How to approach the aircraft and how to manoeuvre around it, both from the driver cabin and the operator cabin
- Order communication including DTS operation
- Active training in all spraying techniques on the aircraft or on simulators
- Visual check of the treaded areas – PDAC procedure

The qualification only applies to the current season and has to be updated with a refresher training after a maximum of twelve months.

6.2. De-Icing Supervisor – SAE Qualification DI-L30

Only experienced de-icing operators can qualify for the position of a de-icing supervisor, thus always being qualified as DI-L10, L20 and L30B, too. The de-icing supervisor also has to do the refresher trainings for de-icing operators every year with a positive result of the exam and a successful participation in the practical training.

The de-icing supervisor plans the distribution of the de-icing orders and is the contact person in these matters for the crews. He/she can be contacted via radio or phone at any time. The de-icing supervisor is also the link between the crew and the de-icing operator if they cannot communicate directly due to operational reasons. He/she carries out contamination checks and decides upon the result if a pre de-icing[3] is necessary and can also support the de-icing operators with the PDAC or other tasks at any time.

6.3. De-Icing Instructor – SAE Qualification DI-L40

The trainings are only conducted by trainers with qualification level DI-L40, who themselves obtained their license from internationally recognized and qualified trainers according to ICAO/IATA Global Standard. Here also, a several-day refresher training takes place once a year to obtain a new license. Qualification DI-L40 also always includes the qualifications of DI-L10, L20, L30 and L30B. The trainer has to be qualified by the Head of De-Icing Training once a year.

6.4. Fluid Quality Inspector (Laboratory Staff only) – SAE-Qualification DI-L60

The Fluid Quality Inspector is certified by the Head of De-Icing Training once a year and is responsible for the quality checks of the ADF fluids. The Fluid Quality Inspector is entitled to train other employees on this.

6.5. Head of De-Icing Training – SAE Qualification DI-L70

The head of de-icing training is responsible for the entire planning, controlling and carrying out of trainings and de-icing. Qualification DI-L70 also includes all lower qualifications.

[3] Is carried out on request by the airline and varies according to the season.

7. Principles of Aircraft De-Icing

What is aircraft de-icing actually? First of all, aircraft de-icing means that an aircraft contaminated with snow, ice, frost or hoarfrost has to be cleaned from these contaminations, thus preventing all possible negative impact on the flight characteristics of the aircraft. Furthermore, an aircraft can be protected against re-icing during the de-icing process. Thus, aircraft de-icing consists of two major components, the de-icing and the anti-icing. Both methods are mentioned below[4].

It always depends on the weather conditions and the traffic volume which method when and how is to be applied. These two factors determine if the chosen method provides an effective protection for the aircraft and thus for the passengers and the crew until take-off. In order to guarantee this, time coordination is a further and often the more important factor beside the choice of method. Therefore, a well-functioning and cross-company team work between the de-icing team, cockpit crew, ground handling and air traffic control is absolutely necessary.

There are different methods in aircraft de-icing. FKB only offers de-icing with liquid de-icing agents (ADF fluid).

8. Clean Aeroplane Concept

The Clean Aeroplane Concept is an essential aspect in aviation safety. All aircraft whose surfaces are contaminated with frost, ice, snow etc., cannot be considered as clean. An aircraft is regarded as clean only once all surfaces have been completely cleaned from contamination and if it is protected against re-icing. Here, it is important to ensure that a second layer of fluids as protection against re-icing will never be sprayed on the previous applied layer. If an additional application has to be carried out, a complete de-icing/anti-icing process has to be performed. Attention must be paid to the entire removal of possible residues of the previous application. It is not permitted to only conduct the anti-icing procedure.

9. De-Icing Fluids – ADF Fluids

Aircraft de-icing fluids are specified by the SAE and are produced in four different types. The main component of these fluids is propylene glycol and additives for the corrosion protection as well as food colouring for identification. This is important to make clearly visible, which ADF fluid is used. Types II to IV additionally contain a thickener.

The ADF fluids used by FKB during the de-icing season 2020/2021 are:

Type:	***Name:***	***Manufacturer:***	***Composition:***	***Colour:***
Type I	*Safewing MP I 1938 Eco (80)*	Clariant	80 % glycol 19 % water 1 % additives	orange
Type II	*Safewing MP II Flight*	Clariant	50 % glycol 48 % water 1 % additives 1 % thickener	yellow

Table 1: overview of de-icing fluids used

[4] According to the requirements of SAE AS 6285C (Aircraft Ground De-Icing/Anti-Icing Processes)

At Cologne Bonn Airport only ADF fluids Type I and Type II are used. The mixing of Type I with water is carried out automatically and proportionally according to the temperature. The Type II is always cold applied and at a concentration of 100 %.

9.1. ADF-Fluid Type I

Type I is a so-called Newtonian liquid and behaves physically like water. It runs off proportionally. Type I is always used diluted. An undiluted use has no better effect as the physical property of the fluid already decreases at a concentration at 70 %, meaning that the freezing point increases. According to the manufacturer the use at full concentration of 100 % is not permitted.

The mixing ratio water/ADF fluid Type I depends on the OAT, respectively ATT[5]. A further factor for calculating the mixing ratio is the LOUT[6].

9.2. ADF-Fluid Type II

Type II is a non-Newtonian liquid, which contains a thickener and therefore develops a pseudo-plastic property. It behaves like solid material at low shear forces and only shows liquid behavior at higher shear forces. Above a take-off velocity of approximately 85 kn (158 km/h), also called shear rate, a shear force is reached where the Type II runs off the aircraft surfaces.

Type II is primarily used for anti-icing and forms a thin protective layer on the sprayed parts of the aircraft. Because its structure is long-lasting and solid on the surfaces of both the aircraft and the wings, even if in this case limited until the starting process, it prevents snow or other contamination from getting onto and freezing on these surfaces.

FKB always uses Type II undiluted, which means at a concentration of 100 %.

9.3. ADF-Fluid Type III and IV

Type III and Type IV have similar properties as Type II. However, they are not used at Cologne Bonn Airport at the moment.

9.4. Potential Hazard – Thickener

When the water and later on the glycol have separated out from the ADF fluid Type II (also Type III and IV) after a certain time, thickener residues in the form of a grey powder remain. These residues still have the ability of binding fluids up to 150 times their original volume. However, as there is no glycol left, the freezing point of this mass is at zero degrees. If these residues get stuck in gaps of the control elements and even only start to bind air humidity, there is a risk of ice chunks forming which can result in a negative impact on the controllability of the aircraft.

The responsibility for the checks for residues remains with the airlines. These residues may only be removed mechanically, with hot water or ADF Type I.

[5] See also cold soak effect
[6] Lowest Operational Use Temperature – see explanation of terms

10. ADF Checks

Before ADF are used, they are regularly tested in accordance with the requirements of SAE AS 6285C. The different procedures/requirements are as follow:

10.1. Taking of samples

There are two different procedures to take samples of ADF-Fluids:

- Samples from storage/tanks: A sample bottle (minimum 0.5 liters) is filled via an outlet or directly taken from the tank.
- Samples from the nozzle: A sufficient amount is sprayed from about three meters away at an angle of about 45 ° against a free-standing metal sheet. The down flowing fluid will collected in a sample bottle (minimum 0.5 liters). The sheet must be washed off with hot water before any further sampling.

10.2. ADF Checks upon Delivery

Upon delivery, samples of all ADF fluids are drawn by the ADF coordinator and refractometer values, viscosity and acidity are measured and documented in an internal laboratory. The results will be checked against the values specified by the manufacturer. If the values are within the permitted limits, the ADF may be filled in the tank facilities. Should any of the values exceed the limits specified by the manufacturer, delivery will be rejected.

10.3. ADF Checks from Tank Facilities before the Season

Before the season, the ADF coordinator takes samples of the de-icing fluids from the tank facilities which are then sent to an approved laboratory. The laboratory communicates in written form if the testing was positive or negative. In case of a negative result, a second sample is drawn and returned for re-examination. If the testing is negative again, the de-icing fluid must not be used.

At the start of the season, the de-icing vehicles may only be filled from the tank facility if a positive test result is provided by the manufacturer.

10.4. ADF Checks from De-Icing Vehicles before the Season

Samples of the de-icing fluids are also drawn from the fueled de-icing vehicles' tanks and spray nozzles which are then sent to a laboratory. Again, a written confirmation of a positive or negative result will be sent. In case of a negative result, a second sample is drawn and returned for re-examination. If this test is negative again, the de-icing fluid must be disposed from the respective tank of the de-icing vehicle. In this case, the de-icing vehicle will be completely checked, including all relevant components (tanks, tank lines, pumps and nozzles).

10.5. ADF Checks from De-Icing Vehicles in Active Operation

Beside a visual check, the refractometer values are measured by the De-Icing Supervisor using a digital refractometer. It is essential that the result complies with the specifications of the manufacturer. If this is not the case, a second sample is drawn and examined. If again this test is negative, the vehicle shall not be used and is furtherly checked by the vehicle maintenance.

The refractometers are monthly checked for proper operation. All ADF and refractometer checks are documented and archived.

10.6. ADF Checks upon need

If a contamination or deterioration of the liquids (Type I or Type II) are suspected, samples are taken from each de-icing vehicle or tank storage concerned and sent to a laboratory. For Type II, this also takes place in the event of maintenance work on the pumps or spray systems. If the result is negative, than the necessary steps will follow as described in Chapters 10.3 and 10.4.

11. Explanation of Terms in Aircraft De-Icing

In aircraft de-icing, there are several terms related to methods and procedures that have to be understood.

11.1. De-Icing with Fluids

"Removal of any form of contamination such as ice, slush, snow, hoarfrost etc. with a liquid that is heated up to at least 60° C and whose liquid ratio is adapted to the relevant temperature."

A mixture of water and ADF fluid Type I is sprayed on the aircraft surfaces at high pressure and at a temperature of at least 60° C until all contaminations are removed from the aerodynamically critical areas, if required also from the fuselage. Furthermore, the heat causes surrounding contamination to detach more quickly from the underside.

11.2. Anti-Icing – Protection against Re-Icing with Fluids

"By spraying a protective layer on the aircraft, it will be protected against re-icing for a certain time frame, which can be seen in the HOT tables. The liquid serves as a protective layer and must be concentrated in a way that it cannot freeze. "

ADF Type II is sprayed cold and without pressure on the aircraft surfaces, or at least on the aerodynamically critical surfaces. It forms a protective film with a smooth surface and protects these areas against re-icing for a time frame depending on the weather conditions. The protection is guaranteed as long as the ADF fluid can absorb precipitation.

The following principle applies: Only a clean aircraft may be protected against re-icing!

11.3. LOUT – Lowest Operational Use Temperature

Every de-icing fluid or antifreeze has an own freezing point, meaning the temperature at which the fluid freezes. When this temperature is reached, of course, any protection against re-icing is no longer guaranteed as the fluid alone would freeze on the aircraft surfaces. To avoid this, a so-called safety buffer is taken into consideration when using de-icing fluids. The calculation formula for the LOUT is as follows:

Type I – unthickened fluid	**=**	**freezing point of the fluid minus 10° C**
Type II/III/IV – thickened fluid	**=**	**freezing point of the fluid minus 7° C**

This means, for example, if according to the manufacturer's specifications Type I freezes with a certain mixture (Type I/water) at -15° C, it is only to be used up to -5° C OAT or ATT[7]. For example, if the OAT or the ATT is at -8° C, the LOUT is exceeded and the concentration must be adjusted accordingly.

A binding principle and rule is: If the LOUT is exceeded, there are no holdover times, meaning that the protective effect of the fluid is NOT ensured.

11.4. Holdover Time (HOT)

The holdover time (HOT) describes the so-called protection time against re-icing, which is the time period from the first spraying of the aircraft surfaces in the anti-icing process until take-off of the aircraft. Within this time frame no ice-forming contamination may accumulate on the aerodynamically critical areas.

In their documents SAE AMS 1424/1 and SAE AMS 1428/1, the SAE specifies standards for measurement methods, properties and approval of the de-icing fluids. Among other things, the maximum holdover times against re-icing in different weather conditions are calculated.

The results are currently published by the FAA[8] or the TC[9] (different measurement methods) in so-called HOT tables. These tables are structured according to different criteria (exact weather conditions, material, and setting of the control elements) and are very difficult to evaluate depending on the weather conditions. For calculating the HOT, one needs comprehensive knowledge of the aircraft, airline guidelines, evaluation of weather conditions and most of all current information about the take-off time/departure time. As the de-icing team is not informed about this and the parameters of their evaluation are unknown, too, neither the de-icing operator nor the de-icing supervisor will name a HOT.

Holdover times are calculated only by the pilot in command (PIC).

While communicating the anti-icing code, the de-icing team also informs the crew if a holdover time is not applicable.

11.5. Anti-Icing Code

After completion of the de-icing/anti-icing, the de-icing team communicates the so-called anti-icing code to the crew. This code contains at least six points of information: 1. ADF Type, 2. name of manufacturer/name of fluid, 3. concentration, 4. timestamp, giving information on when the first application of the anti-icing fluid was carried out, 5. actual date and 6. Confirmation that PDAC has been carried out.

Example:
"TYPE II, Clariant, Safewing MP II Flight, 100 %, 14:25 pm, 07.DEC.2020, post de-icing/anti-icing completed"

With this information given, the crew can determine the holdover times with the tables to be used and by evaluating further influencing conditions and factors.

The anti-icing code or information about the de-icing process may also be given in written form using the "De-Icing Info to Crew" sheet. All necessary data is recorded on the sheet in accordance with the de-icing procedure.

[7] See also Cold Soak Effect.
[8] Federal Aviation Administration – US aviation authority
[9] Transport Canada – aviation authority Canada

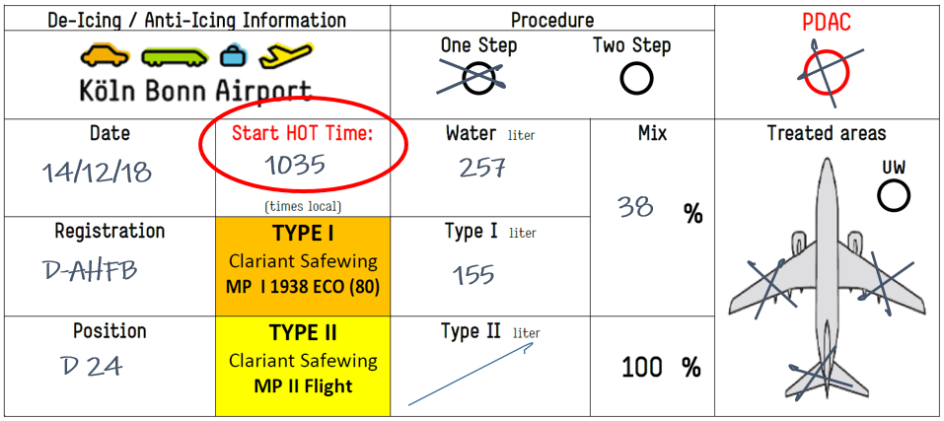

Figure 1: De-Icing Info to Crew

Under certain conditions, the anti-icing code is transmitted with the additional information "no holdover time applicable". This is the case with asymmetrical de-icing, local frost removal, partial de-icing or only underwing de-icing. If a hold over time is not applicable, no time will be entered under "Start HOT Time"!

11.6. PDAC – Post De-Icing/Anti-Icing Check

After every de-icing, the de-icing operator must compulsively carry out visual checks (PDAC) of the entire aircraft for contamination. Here, it is irrelevant if only a partial de-icing or a complete de-icing has been carried out. The result of the check will be immediately transmitted to the crew. On request of the crew, the maintenance department or the airline, the de-icing team carries out this check even without a de-icing order.

11.7. Special Checks

Special checks for contamination have to be carried out with few certain aircraft types[10]. These checks are called “hands on check”, “clear ice check”, “clean wing check” or “tactile check”. Depending on the aircraft type, different parts of the wings are checked for ice formation with the bare hand. The use of different means and tools is usually necessary. Depending on the aircraft type, it is also not always possible to determine ice ridges on the front part of the fuselage, which will disrupt the air flow in front of the pitot tubes.

These checks cannot be carried out by our de-icing team due to a lack of practical experience and technical equipment.

11.8. Obligation of Symmetric De-Icing

Every aviation organization requires that all work in aircraft de-icing must be carried out symmetrically: "Whatever happens on the left-hand side of the aircraft also happens on the right-hand side". Symmetrical de-icing has to be carried out even when only one side or one wing is contaminated. This primarily prevents negative effects on aerodynamics.

11.9. Cold Soak Effect

Cold soaked wing essentially describes a wing that is soaked with cold. The cold soak effect occurs if the temperature on the wing surfaces is lower than the outside air temperature. This means that the reason for

[10] e. g. F70/100 or MD80

the icing is not the cold outside air temperature (OAT) but the temperature of the much colder wings surfaces which were cooled down by a very low tank or kerosene temperature (ATT).

The ICAO/IATA state: "Is the aircraft fuel tank temperature (ATT[11]) lower than the outside air temperature (OAT[12]), the fluid concentration in anti-icing must be higher than at OAT. The use of an only 50 % thickened de-icing fluid is not permitted. If icing is identified at temperatures between -2 and +15 degrees, the tank temperature has to be checked".

To determine the correct concentration, the wings temperature would be the reference here. However, as FKB lacks of the technical possibilities to determine the wing surface temperature, the current tank temperature (ATT) is always queried from the crew and used as a reference.

11.10. Critical Surfaces and No Spray Areas

Each aircraft has several areas which may never be sprayed directly for safety reasons. These include e. g. all sensors, landing gears, the APU and engine inlets, folding wing devices as well as doors and windows. Updated information about no spray areas for each aircraft type may be found in all de-icing vehicles. The entire de-icing staff undergoes a special training for this.

12. De-Icing Procedures

It depends on the weather conditions if only the removal of contamination is sufficient or if the aircraft needs additional protection against re-icing. The different de-icing methods and differences in de-icing procedures are described below.

In aircraft anti-icing, one differentiates between two procedures, the One-Step and the Two-Step procedure. As the terms imply, anti-Icing is carried out in one or in two different steps. It depends on the current overall situation which of these two procedures is chosen. In addition, there are several procedures that are based on strategic decisions.

Regardless of which of these procedures described in detail below was applied, a complete PDAC[13] is performed. The result is communicated to the crew, if required, with the additional information if holdover times are applicable.

12.1. One-Step Operation

Here, de-icing and anti-icing are carried out in one operation. This procedure is recommended when there is only low contamination, no precipitation and if the time interval stipulated in the HOT table between the beginning of the de-icing/anti-icing and take-off is not at risk to exceed. During the one-step operation a water/Type I mix heated to 60 °C at least (temperature at the nozzle) is usually used. It is very important to observe the correct concentration specified by the manufacturer.

As the anti-icing takes place in the same operation, it is mandatory to always calculate the fluid concentration according to the LOUT. The aircraft is only be safely protected if the aerodynamically critical surfaces have been treated with at least 1 l / m² water/Type I mix. This amount only refers to the protection. Therefore, an additional quantity has to be calculated according to needs for the removal of contamination.

[11] aircraft fuel tank temperature
[12] outside air temperature
[13] The final check is based on the Clean Aeroplane Concept.

12.2. Two-Step Operation

De-Icing/Anti-icing takes places in two steps if the aircraft is severely contaminated and there is precipitation and/or take-off is not possible within a short period of time due to slot, traffic, etc., and/or precipitation until take-off is expected so that a thorough cleaning and longer protection until take-off is necessary.

In order to remove contamination, heat and pressure are always necessary. This takes place in the first step with only heated water and Type I. As the mixing ratio depends on the temperature, the amount of Type I can be kept as low as possible by thinning the ratio (no LOUT calculation necessary), thus saving costs for the airline. The actual protection against re-icing takes place in the second step when Type II is applied. We use the Type II only cold and in 100 % concentration.

The aircraft is only be safely protected when at least 1 l/m² of Type II is applied on the aerodynamically critical surfaces.

12.3. Minimum Quantities

To protect against re-icing, a minimum amount of 1 l / m² of ADF is required according to SAE. The following table shows an example of the minimum quantities required, including a buffer for overlap and overspray in order to achieve an even protective layer:

A/C -> / Liter	Airbus A300	Airbus A310	Airbus A319/20/21	Airbus A330/340	Airbus A380	Boeing 733/4/5	Boeing 736/7/8	Boeing 747-800	Boeing 777ER	Boeing C17
Wings	282	300	180	480	910	150	180	695	565	480
Tail	81	70	50	100	220	50	50	180	140	110
W+T	363	370	230	580	1130	200	230	875	705	590

Table 2: overview of aircraft specific consumption rates

This table is not exhaustive and only shows recommended values. The actual ADF fluid consumption depends on further factors. The key factor here is the wind which can strongly influence the direct and loss-free application of the fluid.

12.4. Pre De-Icing/Anti-Icing

FKB offers pre de-icing/anti-icing to customers who do not want to lose time for de-icing after handling processes. This is only carried out in agreement with the customer Aircraft from the night/day stop are pre de-iced/anti-iced up to eight hours prior to the scheduled time of departure (STD) in a similar way as in the Two-Step operation. The difference is that the mixture of water and Type I used in the first step will be mixed according to the LOUT in order to avoid the icing of the mixture in case of a temperature drop until take off.

The de-icing supervisor decides if a pre de-icing /anti-icing is necessary and if it can be performed with respect to the conditions. For example, pre de-icing/anti-icing makes no sense in case of precipitation or if precipitation is expected or if the aircraft has not been preconfigured correctly by the crew or the

technical personnel. This includes especially open doors, flaps etc. or the position of the control elements. If a control element is incorrectly set, there is the risk of fluid accumulating in the wrinkles and the thickener builds up residuals[14].

12.5. Underwing De-Icing

In principle, underwing surfaces are not considered critical. According to different aircraft manufacturers, even a frost formation up to 3 mm is uncritical. The reason for frost or ice formations on underwing surfaces is generally cold kerosene[15]. Here, the de-icing/anti-icing is only carried out on demand of the crew.

Important: Holdover Times do not apply!

12.6. Removal of Local Area Contamination

If only single parts or parts of the aerodynamically critical areas are contaminated, a local treatment of only those parts is permissible. Especially here, it is important that the cold-soak effect is considered.

Important: Holdover times do not apply!

12.7. Propeller De-Icing

On demand and if permitted by the airline, FKB also carries out propeller de-icing, whereby always the bottom blade of the propeller is de-iced with ADF Type I with a broadly fanned out jet. For turning the propeller, the support of a crew member or technician ordered by the airline is needed.

A de-icing of jet engines is not offered by the FKB. Jet engines are defrosted with hot air. If needed and on request, FKB provides a hot air blower.

13. Operational Organization

FKB and the entire de-icing team constantly strive to serve all of their clients on time and to their satisfaction. However, winter operations rarely allow for a reliable planning. Furthermore, other factors influence operating procedures caused by extreme weather conditions, which cannot be controlled by the de-icing team. Airlines have to take this into consideration for every planning.

13.1. Contact Person

The de-icing supervisor is the contact person for active de-icing deployments and dispatch.

Phone:	+49 (0) 2203 40-5072
E-Mail:	deicing-supervisor@cologne-bonn-airport.de or dsv@cgn.de
VHF-Frequency:	121.655 MHz

Table 3: contact details of the de-icing supervisor

[14] See also 9.4. – Potential Hazard Thickener
[15] See also Cold Soak Effect

13.2. De-Icing Order

The airline or the handling agent must request the de-icing for each aircraft separately[16]. The order must be placed at least 60 minutes prior to STD/ETD, otherwise a timely provision of personnel and vehicle cannot be guaranteed. If the weather forecast predicts lowest temperatures of +4 degrees and warmer, the order must be placed at least 120 minutes prior to STD/ETD, otherwise a timely provision of the de-icing team cannot be guaranteed. In urgent or extraordinary cases, the de-icing supervisor can be contacted via the Resource Planning Department by telephone +49 (0) 2203 / 40-2500.

The order must be placed via the electronic system FARMS. The order is only binding for the FKB if it is confirmed via FARMS by the FKB de-icing supervisor. Every airline or handling agent may be provide with access to FARMS on request.

An order cancellation by the ordering party may also be made via FARMS. A cancellation fee may be charged in accordance with the current FKB schedule of fees.

The currently published Terms and Conditions of Aircraft De-Icing of FKB (AGB – Enteisung) apply to all de-icing orders (published on the FKB website http://www.koeln-bonn-airport.de/b2b/vertragsbedingungen-entgelte.html).

13.3. Dispatch

All de-icing orders are always processed in chronological order of receipt. The de-icing supervisor distributes the de-icing order to one or to several de-icing operators/vehicles, which have to be at the handling position ten minutes prior to STD/ETD at the latest. The de-icing supervisor shall be promptly informed about possible delays in order to optimally plan following de-icing orders. If within these ten minutes the starting time of the de-icing cannot be determined, FKB reserves the right to adjust the chronological de-icing orders and to bring forward an order scheduled for a later time due to operational reasons.

13.4. De-Icing Process

The de-icing supervisor determines the scope of the de-icing together with the cockpit crew. This can be done personally or via VHF frequency. The de-icing supervisor can always be contacted via the VHF frequency 121.655 MHz.

De-icing can only be started after the aircraft has been readily configured for this purpose and has been subsequently released by the pilot in command (PIC), or, if the technician/ramp agent is the contact person, then he/she will release the aircraft on behalf of the pilot. The release must always be made to the de-icing supervisor, who then informs the staff on the de-icing vehicles. If the aircraft is released but not readily configured for de-icing, FKB shall not assume any liability for possible damage.

After de-icing and PDAC, the de-icing supervisor communicates the anti-icing code to the cockpit crew. This can also be done in the written form by using the sheet "De-icing Info to Crew".

13.5. Disposal of ADF Fluids

After every de-icing, the handling positions are cleaned with a sweeping vehicle specialized for ingesting ADF fluid Type II, which is then brought to the treatment plant. Currently, there is no recycling.

[16] This does not apply to contractual agreements for pre de-icing/anti-icing.

14. Infrastructure and Vehicles

14.1. De-Icing Locations

At Cologne Bonn Airport, de-icing takes place at the handling positions (Gate De-Icing). Remote de-icing (central position) is currently not carried out. FKB reserves the right to assign a new handling position if a safe and appropriate de-icing at the initial handling position is not possible.
De-Icing Treatment with running engines not available.

14.2. De-Icing Vehicles

The Cologne Bonn Airport vehicle fleet currently includes six modern de-icing vehicles from the Elephant Beta and Beta 15 model series of Vestergaard Company (Roskilde, Denmark). These vehicles are equipped with many sensors, thus enabling the operator as well as the supervisor to monitor most of the safety-relevant parameters of the de-icing vehicle from a remote position. These include amongst others the de-icing fluids, its temperatures in the tanks and at the spray nozzle.

Furthermore, the spraying arms are equipped with contact sensors (proximity sensor), which cause an immediate stop of all further movements of the vehicle and spraying arms when touching the aircraft during the de-icing process. In this case, the de-icing supervisor immediately informs the cockpit crew and discusses further actions according to the SAE AS-6285C regulations.

The de-icing supervisors use a Toyota RAV4 with high recognition value. These vehicles are also equipped with a mobile office and offer all necessary communication options such as telephone, email, internet access and diverse radio equipment.

Vehicle:	Elephant Beta	Elephant Beta 15	Toyota RAV4 de-icing supervisor
Number:	4	2	2
Tank Configuration:	tank 1 with 4000 liters of water, heatable tank 2 with 2000 liters of ADF Type I, heatable tank 3 with 2000 liters of ADF Type II, cold		./.
Mixing System:	proportional mixing system in steps of 1% for the water/Type I mixture		./.
Heating System:	tank 1 (water) and tank 2 (Type I) ca. 80°C spray nozzle ca. 60°C		./.
Communication:	VHF 121.655 Mhz Callsign: Iceman		
Cabin Height:	up to 12 meters	up to 16 meters	./.
Working Height:	up to 21 meters	up to 25 meters	./.

Table 4: de-icing vehicles

These vehicles can be used for all aircraft types of any size.

It has to be taken into account that de-icing vehicles may not be operated at wind speeds (also wind gusts) of 40 kn (74 km/h) and above due to safety reasons. Furthermore, the spraying of the ADF fluids at these wind speeds is not feasible anymore due to drifts.

Year-round vehicle maintenance is conducted by FKB maintenance. Once a year, water and ADF tanks are checked and cleaned by the manufacturer.

14.3. Tank Facilities ADF Fluids

Cologne Bonn Airport has two separate tank facilities for ADF fluids with a total capacity of 360, 000 liters ADF Type I and Type II as well as additional water tanks. Thus, the availability of ADF fluids is guaranteed at any time.

15. Quality Assurance

Cologne Bonn Airport has a separate department inside the business division where internal audits are regularly conducted in order to assure and improve quality, whereby all procedures and training measures in aircraft de-icing are evaluated, too. The evaluations of the neutral observers assure and further develop existing processes.

Further questions and suggestions can be directed to the quality assurance team via email: VerteilerQualitaetssicherungBVD@cgn.de.

16. Safety Management

Flughafen Köln/Bonn GmbH operates a proactive Safety Management System (SMS) with the objective to monitor and continuously improve the safety standards at Cologne Bonn Airport. The principle of “Safety First” applies to all operational processes at all times.

Therefore, it is mandatory to report accidents, near accidents and uncertain incidents. These can be reported to the Safety Management as follows:

- via E-Mail: safety@cgn.de
- in a letter: Safety post-boxes can be found at control points of P5, Terminal 1A, Terminal 2 and at the entrance of the VR building
- on the internet: safety.cgn.de

All reports are always treated as strictly confidential. Further information about the Safety Management System can be obtained from the Aerodrome Manual of Flughafen Köln/Bonn GmbH.

Abbreviations

ADF ..... aircraft de-icing fluid
AMS ..... Aerospace Materials Specifications
ARP ..... aerospace recommended practice
AS ..... aerospace standard
ATT ..... aircraft fuel tank temperature
DTS ..... data transmission system
EASA ..... European Aviation Safety Agency
ETD ..... estimated time of departure
FAA ..... Federal Aviation Administration
FARMS ..... Flight and Resource Management System
FBO ..... Flughafenbenutzungsordnung (Airport User Regulations)
FKB ..... Flughafen Köln Bonn
HOT ..... holdover time
IATA ..... International Air Transport Association
ICAO ..... International Civil Aviation Organization
km/h ..... kilometer per hour
kn ..... knot (nautic)
LOUT ..... lowest oprational use temperature
MHz ..... megahertz
OAT ..... outside air temperature
PDAC ..... *post de-icing/anti-icing check*
PIC ..... pilot in command
SAE ..... Society of Automotive Engineers
SMS ..... Safety Management System
STD ..... scheduled time of departure
TC ..... Transport Canada
VHF ..... very high frequency - ultra shortwave